Field Measurement Of Existing Noise Levels

MATERIALS BUREAU
NEW YORK STATE DEPARTMENT OF TRANSPORTATION
Mario M. Cuomo, Governor/James L. Larocca, Commissioner

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NOISE MEASUREMENT UNIT

MATERIALS BUREAU
New York State Department of Transportation
State Campus, Albany, New York 12232

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PREFACE

This revised manual reflects the experience of two years of operation for the Noise Measurement Unit. A major change is the requirement that all measurements consist of at least 100, rather than 50, 10-second readings. About two-thirds of the past measurements already needed at least 100 samples. This change will not require any past measurements to be redone; they are still valid. It will, however, give stronger assurance that the sample period is truly representative of the entire hour being described.

A second major change is in the traffic classification rules. Past counting of 2-axle, 6-tire vehicles exclusively as trucks has led to high traffic noise level calculation by the prediction program. Study has shown it much better, if not yet perfect, to classify these vehicles as either automobiles or trucks depending on their apparent relative loudness.

More information has been added on site selection, again reflecting our experience. The text of PPM 90-2 has been replaced with excerpts from its successor, FHPM 7-7-3.

Principal author of the original manual was Peter A. Chiefari, P.E., Assistant Civil Engineer (Materials) in the Noise Measurement Unit. His dedicated work in pulling everything together made the manual a reality. These revisions were mainly prepared by William Bowlby, also Assistant Civil Engineer (Materials) in the Noise Measurement Unit.

The hard work and essential contributions of Orlando E. Picozzi, who, among everything else, revised the data forms and instruction, and Richard W. Carlson and Thomas F. Nelson, formerly of the Noise Measurement Unit, were integral to the original manual's preparation.

The manual's development was immeasurably aided by the review and comment of many people, including Wm. P. Hofmann, James J. Murphy, Robert J. Perry, William McColl, Louis F. Cohn, William R. Webster, David E. Suuronen and all Regional Noise Liaison Engineers.

A. D. Emerich of the Engineering Research and Development Bureau was responsible for the final review and preparation of the original manuscript. Numerous early drafts and associated notes and memorandums were typed by Arlene A. Stipano, Jo Simmons, Debie A. Lezatte, and Angel A. Serio.

Special thanks go to Cecilia M. Leonard for typing much of the revised edition.

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INTRODUCTION

In the late 1960's, concern in many circles turned increasingly to our environment. Various laws were passed, designed to achieve minimum quality standards for air, water, and land, and to abate the waste of our natural resources. A fourth pollutant, less frequently recognized, is noise. The collection of sounds created by our advanced industrial society has reached a level that can no longer be ignored. One has merely to stand on a crowded city street corner during rush hour to realize the importance of controlling noise.

A major contributor to the noise in our daily lives is the ever-increasing stream of automobiles and trucks riding our nation's highways. Thus, in 1970, legislation was passed that resulted in noise standards designed to control the increasing noise levels associated with highway traffic. These standards were set forth by the Federal Highway Administration (FHWA) in its Policy and Procedure Memorandum 90-2, Revised in May 1976 as FHPM 7-7-3 (Appendix G).

To implement these standards, and in doing so, to help maintain and improve the quality of our environment, the New York State Department of Transportation has created a program to measure highway-related noise. One outgrowth of this program is the Noise Measurement Unit of the Materials Bureau in Albany, which has overall responsibility for noise measurement for the entire Department. Also, each region has designated a Regional Noise Liaison Engineer (RNLE) whose responsibility is to supervise the regional noise measurement program.

The 11 regional noise measurement units are charged with measurement of noise as it relates to the Department's environmental impact assessment program. The Main Office Noise Measurement Unit's function is to support the regional units with training, equipment allocation and general coordination of a quality noise measurement system. A third group, the Environmental Analysis Section, is also located in the Main Office. One of its functions is to provide support for the regional noise analysis effort.

As a Noise Measurement Technician (NMT), you are the field arm of this organization. It is you, the NMT, who will be measuring noise in the field. This manual is written specifically for you. It's designed to be both a field guide and a reference explaining the basic science of sound, noise, and noise measurement. It has three sections:

I. Sound and Noise Fundamentals.

II. Measurement of Existing Noise.

III. Noise Field Test Methods.

Section I gives the basic science of sound and noise -- what they are and how they are defined for measurement purposes.

Section II deals with the specifics of noise measurement, with emphasis on highway-related noise.

Section III gives field test methods for noise measurement, explaining in detail the equipment and procedures and the necessary paperwork.

One further point -- as a Certified NMT, you have a particularly high level of responsibility. Noise must be measured by strictly adhering to field test procedures. Mistakes in obtaining noise data are not always readily detectable. If the data appear incorrect, the only alternative is to go out and re-measure for verification. Unfortunately, many times this is not possible.

Your measurements will be one factor in transportation decisions. Once you are a Certified NMT, the Department will have to rely on your measurements, and possibly even defend them in court.

Everyone in the state will benefit if we reduce noise levels. Noise is here to stay, but with your help, we can design measures to control it. Doing your job to the best of your ability will help improve our environment.

I. SOUND AND NOISE FUNDAMENTALS

A. Sound Waves

Since we are concerned with noise it seems logical to start with the question: what is noise? The best definition is the most simple. Noise is unwanted sound. Fine. But what is sound? We've taken it for granted since childhood. We hear "sounds." Technically, sound is defined as a wave disturbance moving through an elastic medium at a speed characteristic of that medium. That really doesn't help much. Let's try it this way. On a nice day you're sitting by a lake. The surface of the water is relatively flat. You're fishing for bass. They aren't biting, so you pick up a rock and toss it into the lake. When the rock hits the water it causes waves in the form of rings that move outward for the point where the rock enters the water. The rock has disturbed the water from its equilibrium (flat) level, and the waves move outward and eventually die out.

Now, as we said, sound is also a wave. The difference between the water wave and a sound wave is that sound is a disturbance in the air. More correctly, the sensation of "sound" is caused by the ear detecting changes from atmospheric pressure. When a bass drum is struck, the drumhead begins vibrating (rapidly moving up and down), causing waves in the air, just as the rock caused waves in the water. These waves are detected by our ears as very tiny changes from the equilibrium (or atmospheric) pressure. These pressure changes are converted through the internal workings of the ears into a message that is sent to the brain. The result is that we "hear" the sound of the bass drum.

Water waves, sound waves, and in fact, all waves can be described by two characteristics:

1. AMPLITUDE.

2. FREQUENCY.

In the case of the water waves caused by the rock, the amplitude of the wave is the height of the water above or below the undisturbed (flat) water surface. Another way of saying this would be that the amplitude of the wave is equal to the "magnitude" (height) of the "disturbance" (change in water level) above or below the "reference" or "equilibrium" level (undisturbed flat water surface).

Now suppose a pole were sticking out of the water near where the rock hits. If we counted the number of waves passing the pole for, say, 5 seconds and divided that number by the 5-second time, we would know the frequency of the wave. In other words, the frequency of the wave is equal to the number of

waves occurring in a unit of time. One complete wave is known as one cycle. In the case of the bass drum, when the drumhead is struck it is pushed down. The drumhead then springs back up, completing one cycle. The number of times it springs up and down (vibrates) per unit of time is the frequency of the sound wave produced.

For the case of a water wave, Figure 1 shows the relationship between frequency and amplitude. Case 1 shows an amplitude of 1 in. above and below the equilibrium water level and a frequency of 1 cycle (i.e., one complete wave) in 10 sec, or 0.10 cycles per second. The term "cycles per second" has been given the special name hertz, abbreviated Hz. Therefore, 1 cycle per second equals 1 Hz. In Case 2, the wave has an amplitude of ± 1 in. and a frequency half that of Case 1, or 0.05 Hz. In Case 3, the frequency is the same as in Case 2, but the amplitude is now 2 in., or twice that in the other two cases.

To summarize briefly, noise is unwanted sound. Sound is a wave disturbance in the air similar to a water wave. They are similar because all waves can be described by two characteristics -- amplitude and frequency. For a sound wave, the amplitude is the magnitude of the variation from atmospheric pressure, and the frequency is the number of disturbances per second. Frequency is expressed in hertz, abbreviated Hz.

One further comment -- the sound we will measure in the field is composed of not only one sound wave, but is a summation of a number of separate sound waves, each with a different frequency and amplitude. These different waves add up to produce the overall sound wave. An example of this is an orchestra. Each instrument produces a sound wave, and they all add up to give the orchestra's overall sound.

B. Sound Pressure Level

The human ear is sensitive to a large range of pressure disturbances. The change from atmospheric pressure caused by a cricket chirping at night is very tiny compared to the change from atmospheric pressure caused by a jet engine at an airport, yet the human ear can detect either.

Because of this large range of pressure disturbances that the ear can detect, it would not be practical to compare sound waves on the basis of pressure disturbances. To use the water wave example, this would be like comparing the ripples in a puddle to a tidal wave. So, to compare sound wave amplitudes, we use sound pressure level (abbreviated SPL), which is defined in such a way that the large pressure ranges possible are compressed into a smaller scale. (How this is done is explained in Appendix F.) The units of sound pressure level are called decibels.

The sound pressure level in decibels (abbreviated dB) then allows us to compare sound wave amplitude without the problems that we would have if we tried to compare them directly in terms of pressure disturbances. Figure 2 gives SPLs, in decibels, for various common indoor and outdoor sounds. The SPL of a person talking at a distance of 3 ft is about 65 dB. A jet airplane at 1,000 ft causes a much larger disturbance; hence, the SPL is 105 dB.

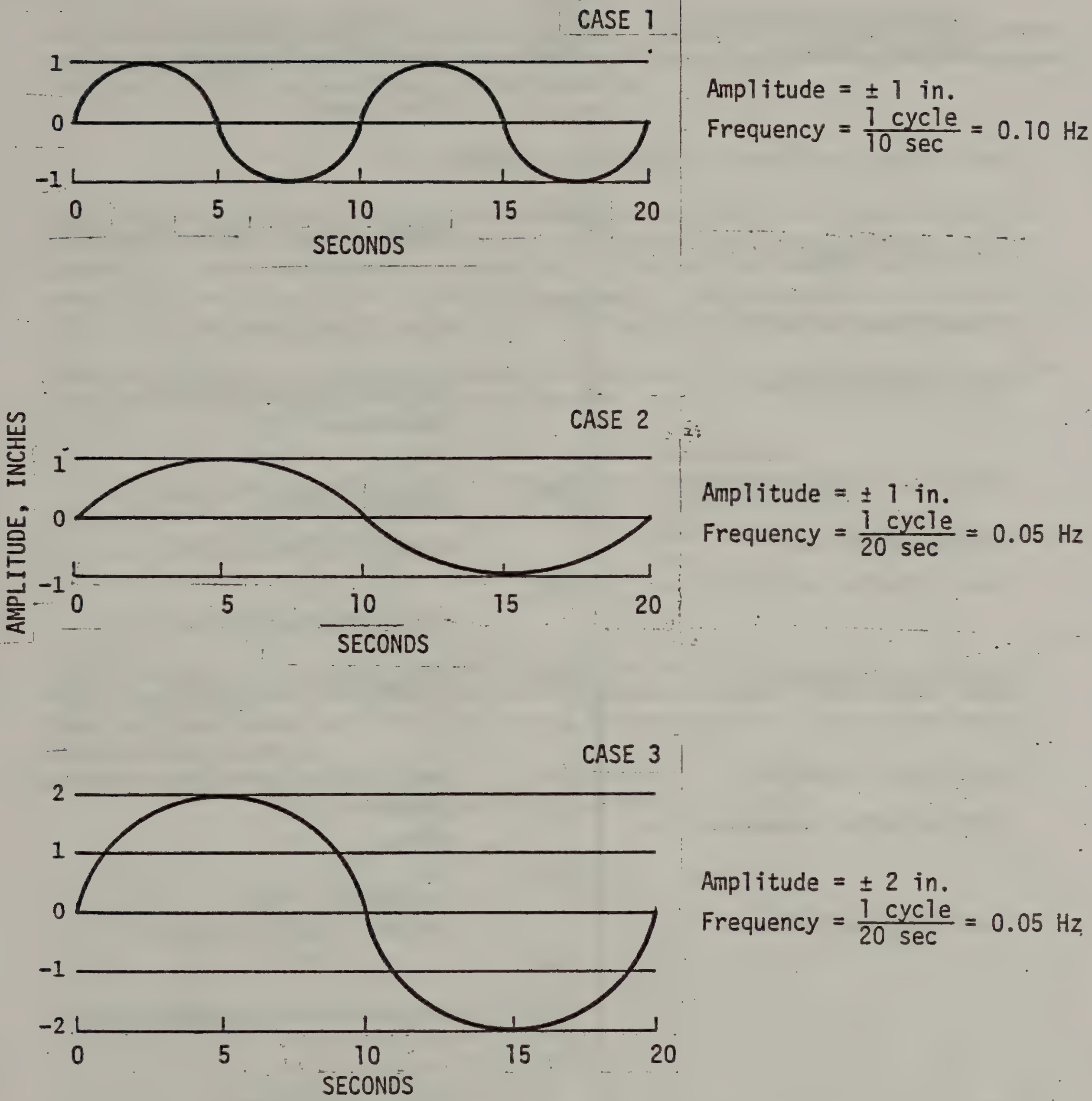

Figure 1. Frequency and amplitude of water waves.

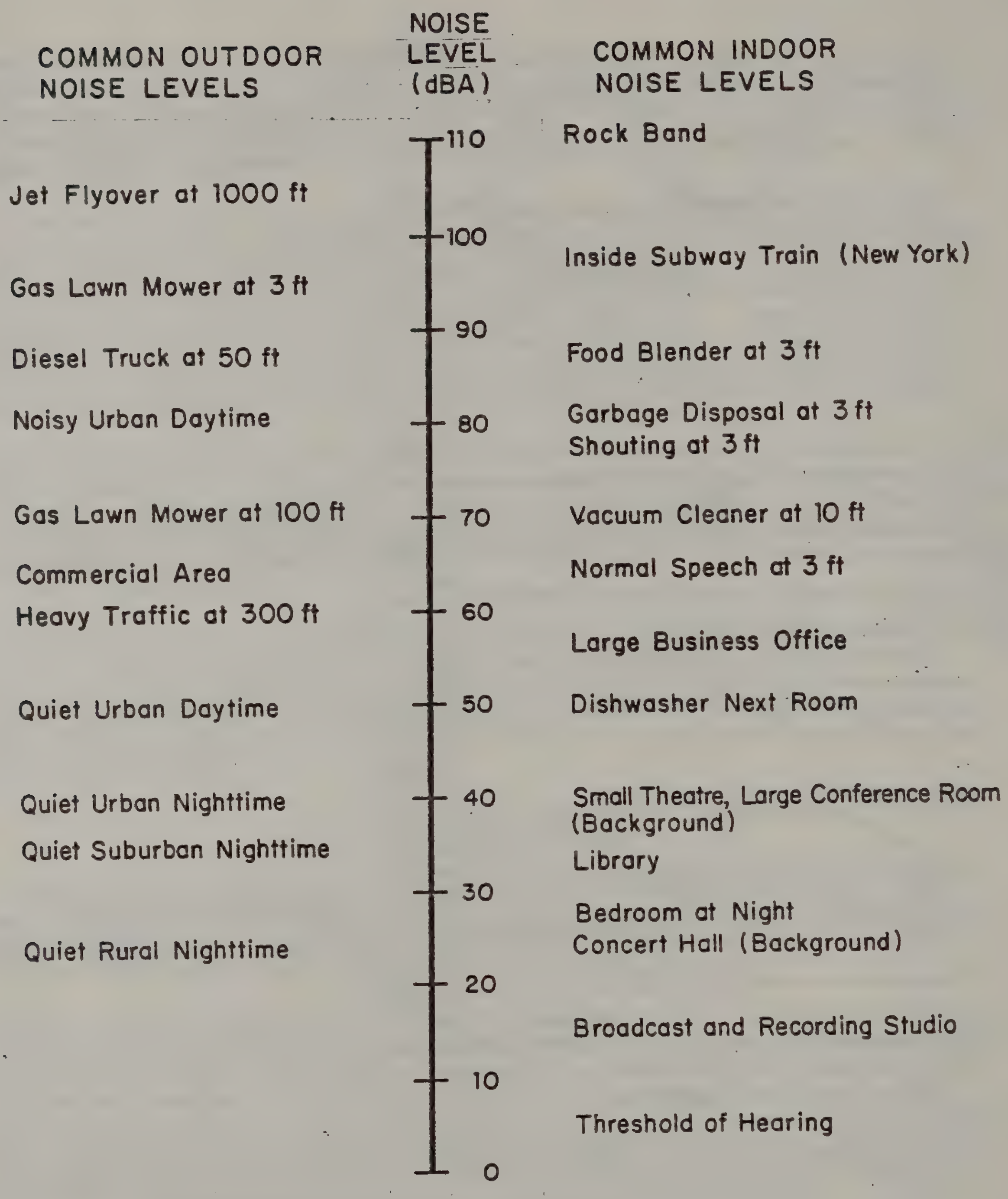

Figure 2. Common indoor and outdoor noise levels.

To summarize again, noise is unwanted sound. Sound is a pressure disturbance and Sound Pressure Level or SPL is related to the magnitude of this disturbance. The units of SPL are decibels, abbreviated dB.

C. Addition of Decibels

There is one important difference between decibels and, for example, feet or pounds. If two boards are each 10 ft long, then their total length is 20 ft. However, if two trucks each create a SPL of 70 dB, then their total SPL is not 140 dB but only 73 dB. (This is because of the mathematical definition of SPL in dB; this definition and a proof of the above are given in Appendix F.)

Using the following table and method, any number of sound pressure levels may be added with an accuracy of ± 1 dB.

When two decibel values differ by	Add the following amount to the higher value
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 9 dB	1 dB
10 or more dB	0 dB

To illustrate, we will add the following levels: 69, 89, 84, 74, and 78 dB. The first thing to do is rank the sound pressure levels in ascending order. They are then added pair-wise, according to the preceding table, beginning with the lowest pair:

69 → =75 → =80 → =85 → =90 dB
74
78
84
89

69 dB + 74 dB = 75 dB
75 dB + 78 dB = 80 dB
80 dB + 84 dB = 85 dB
85 dB + 89 dB = 90 dB

Notice also that for differences of 10 dB or more, the number of decibels added to the higher value is zero. This means that if one sound is stronger than another by 10 dB or more, the lower sound is effectively "drowned out" by the higher one. This effect is called "masking."

D. The A-Scale Weighting Network

Just as the human ear is sensitive to a large range of pressures, it is also sensitive to a large range of frequencies. For most people, the normal fre-

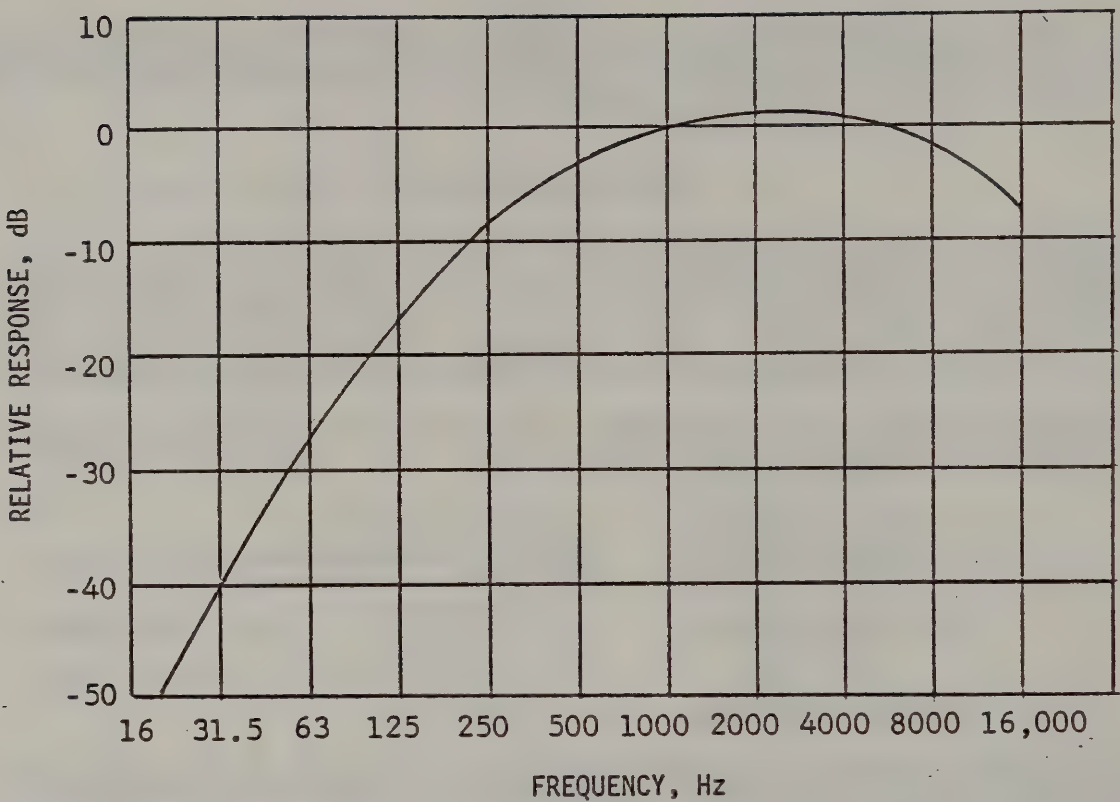

Figure 3. Electrical frequency response specified for the A-scale filter of sound level meters (ANSI SI.4-1971).

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quency range of hearing is from 20 to 10,000 Hz, and in some cases as high as 20,000 Hz. However, the human ear does not "hear" each frequency equally. It is less sensitive to low-frequency sound than to high-frequency. Since we want to measure noise in a way that compares closely to the human ear's sensitivity, the A-scale weighting network has been devised.

The A-scale network (within the measuring equipment) electronically adjusts some of the higher and lower frequencies when the SPL is measured. The sound-measuring device then responds in a manner very close to the response of the average human ear, givin us a good idea of how the average person would perceive that sound.

The A-scale changes the SPL as shown in Figure 3. From this graph it can be seen that at 100 Hz, the SPL is diminished by 20 dB. At 1,000 Hz the SPL is not changed at all, while at 2,000 Hz, the SPL is increased by 1 dB.

From this point on, we will no longer use the term SPL in dB, but rather the term "sound level." By this we will mean an SPL measured in dB with an A-weighting network. Thus, sound level will mean the result of an A-weighted measurement. Any sound level will then be an approximation to the response of a human ear. Also, for our sound levels from here on, the results will be

reported as dBA, not dB. Thus, if the sound level of a passing car were measured, the results would be reported as 67 dBA, not 67 dB.

E. Sound Reduction and Reflection

When the rock in the water-wave example hit the water, waves were created and radiated outward at a certain speed. As they moved farther and farther out, they became smaller (attenuated) until they finally disappeared.

The same thing happens with a sound wave -- the farther from the sound source, the smaller the disturbance. Consequently, the sound level decreases with distance from the source. For example, the farther you are from a truck moving down the highway, the lower the sound level will be. If there is a high concrete wall between you and the highway, the sound level will be still lower, because some of the sound the truck generates will be reflected away by the wall. This can also work in reverse. If a building is close behind you, some of the sound waves may be reflected back to you, causing the sound level of the truck to be higher than it would be without the reflected sound. Rows of houses or possibly even a densely wooded area between you and the highway may also reduce the sound level.

The reason for mentioning these facts will become apparent later in this manual when we discuss the selection of measurement sites. For now, however, it is important to remember the following rules which apply to a site having an unobstructed view of the highway:

1. For a single car or truck proceeding down a highway, for every doubling of the distance from the road the sound level should drop approximately 6 dBA.

2. For a line of cars -- that is, a fairly uniform stream of traffic -- for every doubling of the distance from the road the sound level should drop approximately 3 dBA.

"Doubling the distance" means that if you are 50 ft away and get a sound level of 59 dBA, then at 100 ft you should get 53 dBA for a single car and 56 dBA for a stream of traffic.

This concludes our discussion of the fundamentals of sound and noise. It has been very basic. Appendix E of this manual gives references for further reading.

II. MEASUREMENT OF EXISTING NOISE

A. Traffic-Related Noise Sources and Existing Noise

1. Existing Noise

In Section I, we explained how the sound we measure is not simply one wave, but a combination of waves like an orchestra. Likewise, in the field, the activities usually occurring around a site produce a combination of sounds. This combination of sounds is commonly referred to as existing or ambient noise.

The existing noise level is obtained by measuring the sound level produced by those activities normally occurring in the site area. In the case of a site located close to a highway, a major portion of the existing noise will be from vehicles traveling down the road. If we are near a highway close to an airport, existing noise will also include noise of the aircraft. If we are in an isolated area, birds, crickets and rustling leaves may produce all of the existing noise. We will say more about the subject later. For now, it is sufficient to remember what existing noise is.

2. Automobiles, Trucks, and Other Vehicles

In most cases, we will be measuring existing noise whose major component is from highway traffic. Extensive measurements have shown that you can expect automobile sound levels to vary between 60 and 75 dBA and truck sound levels from 75 to 90 dBA or more at about 50 ft from the roadway. The large variations are due to such things as vehicle acceleration, speed, and condition; tire tread condition and type; and roadway surface roughness and grade.

Since there are relatively large variations between automobiles and trucks, we can see that it is very important to know how many trucks go by and how many automobiles; if we had only trucks going by, the existing noise level would generally be higher than if we had only cars.

Knowledge of the number of cars and trucks is necessary to help predict future sound levels, since it is reasonable to assume that altering an existing highway or putting a new highway in an area may increase traffic or change the relative number of automobiles and trucks, possible resulting in higher noise levels. For these reasons, traffic counts will be made during measurements.

Now, although this may sound odd, for our measurements what is a car and what is a truck? And how about motorcycles? Everyone has heard a

souped-up sports car. Some are very loud. Some motorcycles are also quite loud -- as loud or louder than some trucks. To solve this problem, we will observe the following rules in classifying vehicles:

1. Any four tire, two axle vehicle including sports cars, pick-up trucks, and small vans will be counted as an automobile.

2. Any two-axle, six-tire vehicle or motorcycle will be counted as a medium truck.

3. Any three or more axle vehicle including commercial busses will be counted as a heavy truck.

Now, let's look at how we should go about taking measurements.

B. Basic Principles of Existing Noise Measurement

Measurement of noise for evaluation and possible control requires 1) a device that measures sound level, 2) a plan of where and when to measure, 3) a measurement method for collecting the noise data, and 4) a method to record and reduce the data. State more simply;

1. Equipment -- what do we use to measure?

2. Site and time selection -- where and when do we measure?

3. Method -- how do we measure?

4. Data Recording and Reduction -- what do we do with the measurement?

1. Measurement Equipment: The Sound Level Meter

Noise can be measured in many ways, using many types, sizes, and kinds of equipment. The most basic piece of equipment for measuring sound level is the sound level meter. All sound meters perform the same basic function -- they measure the sound level. Components and controls are

similar on most models. Components usually consist of a microphone, an amplifier, an A-weighting network, and a meter calibrated in decibels. The controls include an on-off switch, a meter response setting (fast-slow), a battery check switch, a weighting network selector, and a range switch. In addition, there is usually a calibration adjustment. (The functions of each of these controls for our equipment will be explained in Section III.)

Just as with any piece of equipment, the sound level meter has certain operating limitations. For instance, the microphone attached to the meter will not work if the humidity is too high or if it becomes dirty. Temperature extremes can be detrimental to the meter's electronics, especially prolonged exposure to direct sunlight. High winds may also result in erroneous measurements.

2. Selection of Measurement Sites and Times

Once the equipment to perform the measurements is chosen, the next step is to decide where and when to measure. Deciding "where" is actually a two-stage process. The general location of a measurement site is normally indicated on a map of a proposed project. This site is selected by careful study of the map, and/or by preliminary field investigation. Sites are generally chosen to measure existing noise levels near noise-sensitive activities such as schools, hospitals, churches and houses. They are also chosen to provide a general picture of the noise level over an entire area. The exact site location in the field is selected by the measurement team.

The most important fact to remember in selecting a site is that measurements need to be representative of that area and its typical activity. So, in general, the equipment should not be set up close to a building, or a sign, or a parked car, or any object that might distort the sound field. (However, it should also be understood that sometimes measurements may be needed from an area full of reflective surfaces (e.g. trees in a wooded area). These sites should be measured as specified by the RNLE, noting any special circumstances that are present.)

It is also important to know the location of the site. This should be done by drawing a small diagram showing approximate footage from a distinguishing landmark or from the roadway if the site is near one. The distance from the landmark or roadway should be paced off, or tape-measured if so desired by the RNLE. The diagram and description should be sufficiently clear and complete to allow another measurement team to locate and set up at the exact spot.

The "when" to measure may be very dependent on the location. We may want to measure a particular site at a particular time. For instance, we may want to measure the effect of a highway on a site located close to a school. At the time the measurement team is present, school may just be letting out. It may be necessary to come back when classes are in session. In any event, the fact that school was just getting out should be noted along with the time the measurements were taken.

Also, there may be a temporary noise source near the site that is not typical of the usual activity near it. Examples would be a tree-cutting crew, water line repair crew, or a police or fire emergency. Measuring the noise level generated by these temporary activities would bias the description of the area's usual noise level. Our only choice is to try again at a different time or day.

In any case, always be sure to record the time when you made the measurement. The RNLE must have this information to do a correct noise analysis.

3. Measurement Method

Let's assume the site and time have been selected and the sound level meter is operating properly. Now what? If we are near a road the needle on the meter swings up and down as vehicles pass by. Do we read it when the car or truck is 10 ft down the road or when it is right in front of us? What do we do when no vehicles pass by? The noise at a site varies continuously with time -- that is, at any particular time, there is a certain sound level. This sound level changes continuously. Since sound varies with time, it would be best to take measurements as a function of time. By this we mean that we select a time interval -- say 10 seconds -- and every 10 seconds we read the meter whether it is noisy or quiet, or if a vehicle is or is not nearby. The sound level is recorded each time and after a sufficient period we will have accumulated a number of readings. We can then analyze these in some way to obtain the existing noise level at the site.

4. Data Recording and Reduction

At each 10-second interval, when the meter is read, a value for the sound level is obtained. How do we handle these data and reduce them to a meaningful form? We could write down each reading. An easier method would be to check off the readings as we measure them, on a form having preprinted values on it. Then all that would be necessary would be to put a check near the appropriate value each time it occurs.

This brings us to the question of how many readings we take; also, what do we do with them? FHWA currently states its design noise levels in FHPM 7-7-3 on the basis of a quantity called L_{10}. This is the noise level exceeded for 10 percent of the measurement period. L_{50} and L_{90} are also used in some computations, and are the sound levels exceeded 50 and 90 percent of the time period. How do we find these quantities?

Suppose we have obtained the set of 100 readings shown on the next page. L_{10} is the level exceeded 10 percent of the time and there are 100 readings; 10 percent of 100 is 10. Therefore, L_{10} is the sound level assigned to the row in which the tenth reading occurs. So, starting from the top, we count down the readings until we reach the tenth reading. In this case, L_{10} would be in the second group of readings -- that is, 67 dBA since the tenth reading occurs in that group. Similarly, for L_{50} and L_{90} we count

down from the top to the fiftieth and ninetieth readings. L_{50} would be 64 dBA and L_{90} would be 60 dBA. By using L_{10}, L_{50}, and L_{90}, we can numerically characterize the noise environment at the site where the data was collected.

dBA		Total Readings
	L_{10}	
68	X X X	3
67	X X X X X X X X	8
66	X X X X X X X X X X X	11
65	X X X X X X X X X X X X X X X L_{50}	15
64	X X X X X X X X X X X X X X X X	16
63	X X X X X X X X X X X X X X X X	16
62	X X X X X X X X X X X X X X	14
61	X X X X X X X X X X	10
60	X X X X X X X L_{90}	7
		100

Since we only sampled the noise level once every 10 seconds, rather than continuously, we're not definitely sure that the L_{10} we measured was the actual L_{10} for the entire time period. That is, when we take a set of readings and compute L_{10}, we are actually estimating it based on the set of readings. The larger the set of readings (100, 150, 200, etc.) we take, the more accurate the estimate becomes. This leads us back to the question of how many readings are needed to get an accurate estimate. In order to answer, we first have to determine how accurate we want L_{10} to be.

Say we take 100 measurements and find L_{10} to be 78 dBA. How accurate is the 78 dBA number? Another way of asking how accurate the number is, is to ask how much confidence can be placed in it. If we took 100 readings and got an L_{10} of 78 and then took 50 more and it was still 78, we might feel pretty confident that 78 is a good estimate of L_{10}.

We have decided that for our purposes we want to be 95 percent sure that our measured L_{10} is within $\pm$ 3 dBA of the actual L_{10}. That is, we want to find $L_{10} \pm 3$ dBA with 95 percent confidence. Through the statistical analysis techniques explained in Appendix D, a table was developed to allow us to check if our data meets this requirement. Its use will be explained in Section III.

As discussed above, FHWA currently states its design noise levels on the basis of L_{10}. The FHWA, however, also recognizes Leq as a noise descriptor. Leq is the "equivalent" noise level. It represents the sound level which, if it were held constant over the specified period of time, would yield the same amount of energy as the actual

fluctuating noise. In other words, Leq is the mean of energy or intensity level over a specified time period during which the sound level fluctuated. The value of Leq can be found in one of two ways, either by continuous evaluation with the proper measurement instrumentation or by individual closely spaced samples over small intervals of time. Leq is defined as:

$$(1)\quad Leq = 10 \log \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} 10^{L(t)/10} dt \quad .$$

It may be approximated, however, as the logarithmic sum of a series of discrete samples of sound level expressed as:

$$(2)\quad Leq = 10 \log \frac{1}{n} \sum_{i=1}^{n} 10^{Li/10}$$

Li = sound level
n = number of short duration intervals.

Formula 2 is simply ten times the log of the average acoustic energy in many consecutive samples.

Now that we have defined both L_{10} and Leq we can compare them. Research has determined that there is a correlation between L_{10} and Leq. The FHWA recognizes this and accepts the following correlation:

$$L_{10} = Leq + 3dBA.$$

Although the FHWA accepts the above correlation and recognizes both L_{10} and Leq as design noise levels they prefer that we use either L_{10} or Leq in our analysis, not both. We therefore note both Leq and L_{10} on the data sheets used in Field Test Mehtod Two and leave the final choice of a descriptor to the analysts.[1]

We have now looked at the what, where, when, and how of measuring existing noise, and this concludes our general discussion. What remains are the specific field test methods we will use when measuring existing noise.

III. NOISE FIELD TEST METHODS

A. Method 1: Measuring Existing Noise Level by the Check-off Method

1. Scope

This test method prescribes procedures for measurement of existing noise levels, using the Bruel and Kjaer (B&K) Type 2206 precision sound level meter. Instructions for documentation are included. (For those regions using the B&K Type 2205 meter, all procedures apply but attention should be paid to equipment limitations, possible differences in calibration, etc.)

2. Equipment

a. Equipment Required

1. B&K Type 2206 precision sound level meter with Type 4148 condenser microphone.
2. B&K Type 4230 calibrator.
3. Windscreen.
4. Wind velocity meter.
5. Extension cable.
6. Tripod.
7. Clipboard and counter.
8. Sling psychrometer.
9. Stopwatch.
10. Spare batteries.
11. Data sheet (BR320a).

b. Equipment Descriptions

1. Sound Level Meter with Condenser Microphone

This meter is a battery-operated precision instrument used to determine SPL in dB (Fig. 4). Its features and controls are as follows:

a. Power Switch

This is a four-position switch marked "off," "fast," "slow," and "batt." "Off" is self-explanatory, "fast" and "slow" refer to how quickly the meter responds to an incident sound wave, and the "batt" position allows the battery to be checked.

b. Range Switch

This is turned to change the reading range of the meter. The range indicator window on the meter shows the range value selected. The meter scale (Fig. 5) has a range of 20 dB. When the needle points to the right of the line beneath the range indicator window, the sound level is the meter scale reading plus the figure in the window. Readings to the left of the line under the window are subtracted from the figure in the window. It is best to attempt to keep the needle in the positive portion (e.g. the 75-dB reading in Fig. 5) since this is easier to read and more accurate.

c. + 10 dB Button

This increases the range of the meter face by automatically adding 10 dB to whatever value is in the range indicator window.

d. Sensitivity Adjustment

This small recessed screw will change the meter's needle position for calibration. Do not press screwdriver in hard.

e. Weighting Network Selector

This should be set on "A" at all times.

f. Microphone

This precision condenser microphone (Fig. 6) can be unscrewed and removed from the meter. Take care not to damage the contacts when removing it. Also, do not remove the grid on top of the microphone at any time. If the meter and microphone are taken to

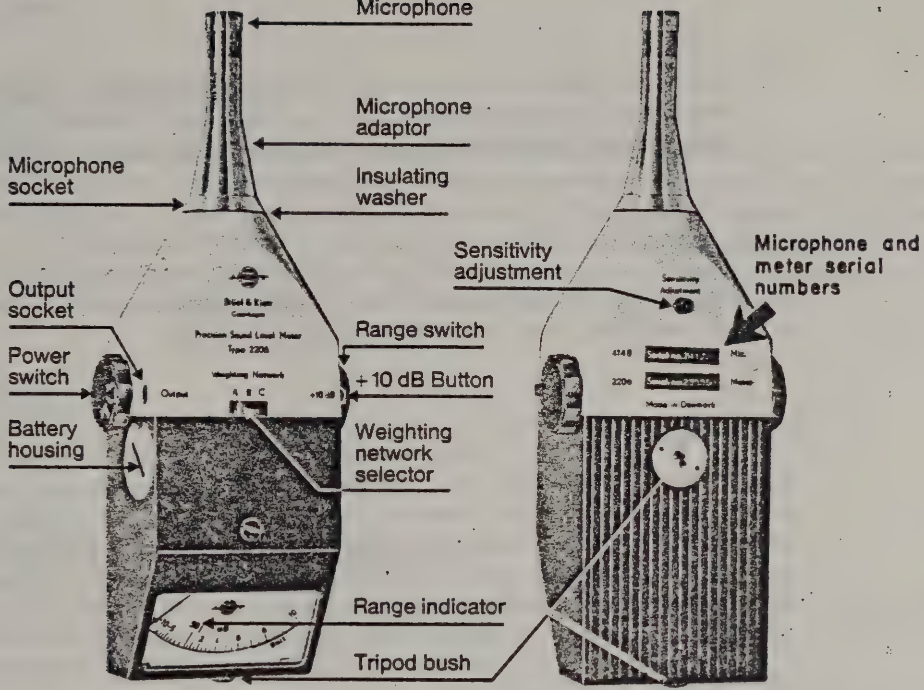
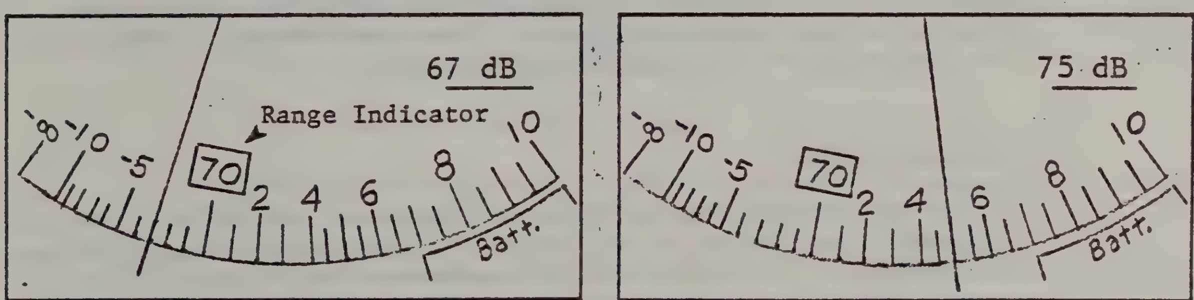


Figure 4. Front and back views of the sound level meter and microphone.



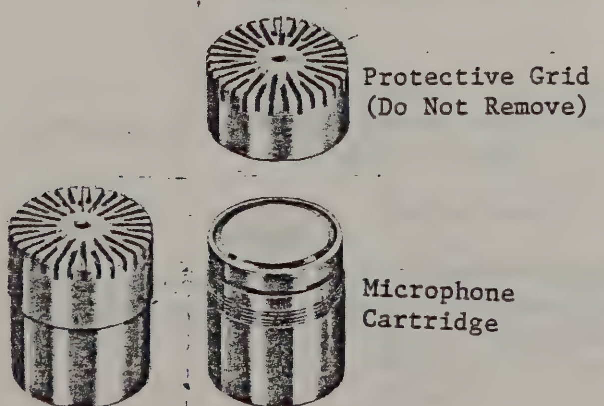


Figure 5 (above). Meter scale at two decibel levels.

Figure 6 (left). Condenser microphone.

a site inside a warm vehicle on a cold day, condensation may form when the microphone is set up outside. Under such conditions, transport the microphone and meter in your car's trunk.

2. Calibrator

This is used to calibrate the sound level meter. The calibration signal for the Type 2206 meter is 93.8 dB.

3. Windscreen

This round foam ball is placed over the microphone to eliminate noise caused by wind blowing across it. It is effective up to 12 mph, at which speed measurements are to be discontinued. Always use the windscreen, even on still days, since it also protects the microphone from dust.

4. Wind Velocity Meter

Instructions for use are printed on the back of this meter: "To use, face the wind. Hold meter in front of you in vertical position and with scale side toward you. Do not block bottom holes. Height of ball indicates wind velocity. For high scale, cover hole at extreme top with finger." Take wind velocity readings at the beginning of each measurement period.

5. Extension Cable

Always use an extension cable. It keeps the bulk of the meter and operator from causing a reflection of sound waves, thus affecting the reading. It also allows the operator to sit away from the tripod during readings. The cable connects the meter to the microphone. Do not touch any of the contacts, and keep them as clean as possible.

6. Tripod

Support the microphone on the tripod 4 to 5 ft above the ground.

7. Clipboard and Counter

A legal-size clipboard is supplied with a counter attached. The counter can be used to keep track of the number of readings or to aid in vehicle counts.

8. Sling Psychrometer

Noise cannot be measured when the relative humidity rises above 90 percent. Higher humidity causes condensation on the microphone, rendering it useless until it dries. The psychrometer thus is used to determine relative humidity. The manufacturer's operating instructions are reproduced on the next page. Measure relative humidity twice daily, usually in the morning and afternoon.

9. Stopwatch

Use for readings every 10 seconds.

c. Calibration of the Sound Level Meter

The calibrator has a calibration signal of 93.8 dB at 1,000 Hz. When the calibrator is placed on the microphone, the meter should read 93.8 dB. If it does not, adjust the calibration as follows:

1. Set the range indicator on 90 dB, warm up for 1 to 2 minutes, and check that the microphone and adapter are firmly screwed on.

2. Turn the power switch to "batt" and check the battery. The needle should swing to the red portion of the meter window. If it does not, replace the meter battery.

3. Turn the power switch to "slow."

4. Place the calibrator on the microphone. Be careful not to damage the plastic adaptor on the calibrator.

5. Press the button on the calibrator.

6. Adjust the meter to read 93.8 dB by turning the sensitivity adjustment screw on the back of the meter with the small screwdriver provided in the meter box. Do not touch the zeroing screw on the meter front.

7. The calibrator will automatically turn off after about 1 minute. If the signal lasts only a few seconds, replace the calibrator battery as follows:

   a. Remove the black leather case.

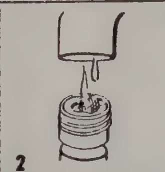
   b. Unscrew the bottom black part of the calibrator housing.

   c. Unsnap the contacts to the battery. Pry the metal clips off. Do not pull on the plastic; this will break the wires.

Remove cap; immerse end of body, to saturate wick.

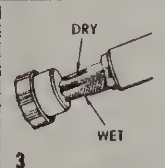
1

Fill psychrometer reservoir with water. Replace cap.



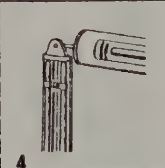
2

Be sure — wick covers "wet" bulb . . . other bulb is dry.



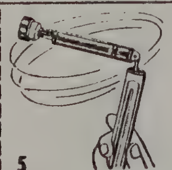
3

Pull body from tube until body hangs free.



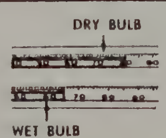
4

Use tube as handle; whirl body about 1 ½ minutes.

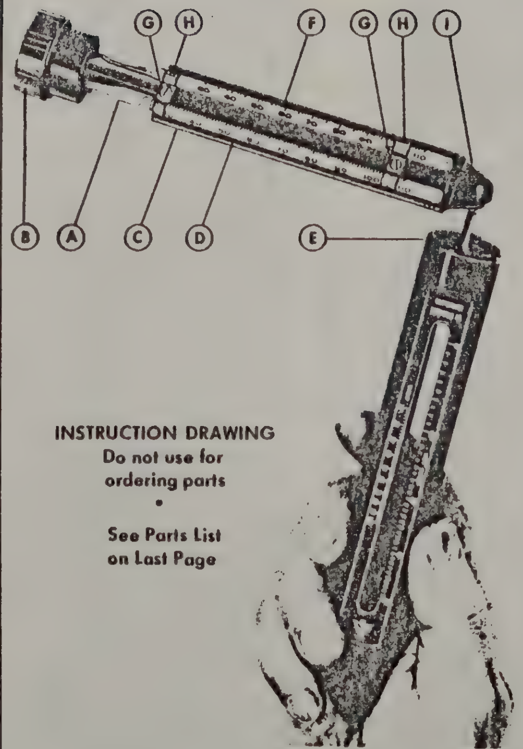


5

Read wet and dry bulb thermometers; replace body in tube.



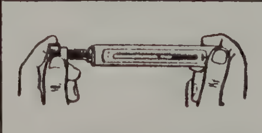
6



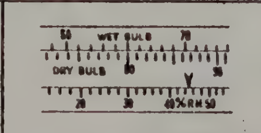
INSTRUCTION DRAWING
Do not use for ordering parts

•

See Parts List on Last Page



7 Set thermometer readings on upper two calculator scales.



8 Read relative humidity % indicated by arrow.

OPERATION

Before using, WICK (A) should be thoroughly saturated with water. Remove END CAP (B) and immerse PSYCHROMETER BODY (C) up to mercury reservoir on the thermometers until WICK is thoroughly wetted. Fill END CAP with water and replace; tighten just enough to prevent leakage.

To use:

1. Be sure WICK (A) is wet and covers mercury reservoir on WET BULB THERMOMETER (D). Be sure mercury reservoir on other THERMOMETER (F) is dry.
2. Pull TUBE (E) clear of BODY so BODY can swivel.
3. Holding TUBE, whirl body two to three revolutions per second (120 to 180 RPM).
4. Continue whirling until temperatures stabilize (1 ½ minutes is usually ample).
5. Immediately read WET BULB THERMOMETER (D) and then DRY BULB THERMOMETER (F). (See application instructions.)
6. Set wet and dry bulb temperatures opposite each other on slide rule type calcuator scales, sliding BODY into TUBE as required.
7. Read % R.H. (per cent relative humidity) indicated by arrowhead on lower scale.

APPLICATION

Wet bulb temperatures should be read first and as quickly as possible for highest accuracy. Delay in reading may cause error. In addition, the wick must be kept clean, saturated with water, and whirled long enough to stabilize temperatures.

Range of the psychrometer is from 10% to 100% R.H. for dry bulb temperatures of 30° to 100°F. or −5° +50°C.

In addition to the above instructions, barometric pressure and other factors will influence exact relative humidity determinations to a very minor degree. For precise work, use psychrometric chart or set of tables such as W.B. No. 235 "Psychrometric Tables for Obtaining the Vapor Pressure, Relative Humidity, and Temperature of the Dew Point" which can be purchased from Superintendent of Documents, United States Government Printing Office, Washington, D. C. However, accuracy of the Psychrometer is satisfactory for all except most exacting work.

MAINTENANCE

WICK (A) should be kept clean; when dirty, cut off below WET BULB THERMOMETER (D) and pull clean section out of END CAP (B) and slide over bulb on WET BULB THERMOMETER.

WICK REPLACEMENT KIT may be purchased separately (refer to parts list). One or two extra WICKS may be kept in END CAP and will help retain moisture longer. Pack WICKS loosely to allow thorough water saturation and ample water supply to WET BULB THERMOMETER.

THERMOMETERS (D) and (F) are replaceable by backing off SCREWS (G) and loosening THERMOMETER CLIPS (H). To separate BODY (C) and TUBE (E), drive ROLL PIN (I) out of eye in PLUG AND SWIVEL ASSEMBLY which then may be slid out back end of TUBE.

d. Replace the battery with a new 9-volt battery.

e. Re-snap the contacts, replace the housing, and return the unit to its case.

The calibrator's leather case is for protection and should be left on except when changing batteries. It protects against dust and the effects of instantaneous temperature changes, as when holding a cold instrument in a warm hand while calibrating. The calibrator has an adapter in the front opening to allow calibration on ½- or 1-in. microphones. Be careful that this adapter does not fall out and become lost. Use only a B&K calibrator on a B&K meter.

d. Maintenance and Repairs

The sound level meter, microphone and calibrator are precision equipment and should be treated accordingly. If they fail to operate properly, return them to the Noise Measurement Unit of the Materials Bureau at the Albany Main Office, either by courier (if available) or by United Parcel Service. (Do not send by parcel post.) When shipped to the region from Albany, the equipment is accompanied by a receipt; check to be sure all that is supposed to be shipped is actually included in the package. When the equipment is returned to Albany, return the receipt, and note if any equipment was lost or broken. Keep each set of equipment together -- don't mix and match with other sets, as that makes it more difficult to keep track of equipment.

3. Test Procedure

The method to be used to determine noise levels was developed by Bolt Beranek and Newman, Inc., and is referred to as "the check-off method." The object is to provide a statistical estimate of L_{10} ± 3 dBA with 95-percent confidence. This means we can be 95-percent sure the actual L_{10} for the site is within ± 3 dBA of the L_{10} we compute from the measurements. The ± 3 dBA are termed "confidence limits" for L_{10}. The following procedure details the steps necessary to obtain acceptable measurements using this method. The measurement team will normally consist of at least two Certified NMTs. The duties of reading the meter, checking off the readings, and counting traffic should be divided between them in a way assuring that all duties are performed. For sites located near high-volume roads or intersections, other personnel may be needed to count traffic. RNLEs should be aware of such a possibility and plan accordingly.

1. Check to see that the meter is operating before going into the field. If the battery has been removed, a standard 1.5-volt size "C" cell should be inserted. An alkaline-type battery is preferred and will give up to 10 hours of meter service. To replace the battery, use a coin to unscrew the battery housing, located on the left side of the meter. Insert the battery with the positive contact outward, and replace the battery housing.

2. Obtain weather data (wind velocity, relative humidity, precipitation) and fill in appropriate information on the BR 320a data sheet (instructions for its completion are given later in this section on pp. 30-32). Operation of the wind meter and psychrometer were described on p. 20. The sound meter's operating temperature range is from 14 to 122 F. Discontinue operations if temperatures are lower or higher, if relative humidity exceeds 90 percent, or if wind velocity is greater than 12 mph.

3. Remove the meter from the box.

4. Turn the power switch to "batt." Check that the pointer lies within the red "batt" mark on the meter scale; if not, the battery should be replaced. Turn the meter off after the battery's condition is verified.

5. Set up the tripod. Attach the microphone extension cable between the meter and microphone, and clamp the microphone to the top of the tripod. Orient the microphone vertically 4 to 5 ft above the ground.

6. Set the range switch to a high value (above 90 dB), to avoid overloading when switching the meter on. The range switch position appears in the window on the meter scale.

7. Turn the power switch to position "slow." Unless otherwise directed, make all measurements with "slow" response.

8. Allow 1 to 2 minutes for the circuits to warm up.

9. Select Weighting Network A with the weighting network selector. Take all readings with A-weighting.

10. Calibrate the meter as described on p. 21.

11. Turn the range switch down until the meter needle reads on the scale between the range indicator window and the + 10 dB mark.

12. Estimate the range within which the noise level fluctuates and assign appropriate values to the noise level lines on the data sheet (BR 320a).

13. Note starting time and at the prescribed interval (10 seconds) glance at the meter. Read the meter at that instant to avoid a biased reading. Try not to anticipate what it will be -- just note the reading as it occurs.

14. Record the A-level reading on the BR 320a data sheet as a checkmark on the appropriate horizontal decibel line, working from left to right within each line as shown on pp. 27-9.

15. Simultaneously keep count of the numbers of cars and trucks passing the measurement site if the location is close to or within sight of a highway.

16. If a disturbance occurs that is not considered representative of the existing level being measured, note it on the data sheet. Use a symbol such as A for airplane or T for train instead of a check (see example 1 on p. 27).

17. After 100 readings, test them by the criteria given in the next section. If they meet those criteria, then the measurement is complete. If not, then take another 50 readings and test them, and repeat as necessary up to a maximum of 250 readings.

18. At the conclusion of the test, re-check the calibration of the meter, re-check the battery, and record these results on Form BR 320a. If the meter is not reading 93.8 $\pm$ 0.5 dB on re-check, repeat the measurements.

19. Note the time finished and record it on the data sheet. Re-check the calculations and be sure that the data sheet is completed.

4. Sample Criteria

After the first group of 100 readings and after each additional group of 50 readings, the following test is made:

1. Counting down from the top of the BR 320a data sheet (and from left to right along each line), circle the test readings shown in the following table (which is also reproduced on the back of BR 320a):

Total Readings	Upper Limit	L_{10}	Lower Limit	Allowable Skew
100	5	10	17	1
150	8	15	23	1
200	12	20	29	1
250	16	25	35	1

For instance, after taking 100 samples, circle the fifth, tenth, and seventeenth samples from the top. These three constitute the L_{10}, flanked by its upper and lower limits.

2. The acceptable limits are $\pm$ 3 dBA or less.

3. In determining if the 100 readings meet the criteria of $\pm$ 3 dB or less, a process called skewing is allowed. By this process,

the upper and lower limits can be shifted by the number of samples listed in the "Allowable Skew" column. The shift can be either up or down. For example, if the criteria are not met (after 100 samples) by the fifth, tenth, and seventeenth samples, the allowable skew according to the table is one sample. Thus the criteria can be tested with the fourth, tenth, and sixteenth samples (skewing up one sample) or with the sixth, tenth, and eighteenth samples (skewing down one sample). Although this skewing procedure will not change the L_{10} value, nor the number of samples between the upper and lower confidence limits, it can sometimes provide the necessary accuracy without requiring further sampling.

Skewing up or down in BR 320a refers to the direction of change as just explained. Note that using the fourth, tenth, and sixteenth samples from the top, instead of the fifth, tenth and seventeenth would be skewing up, not down, and would be so entered on BR 320a. Using the sixth, tenth, and eighteenth samples would be skewing down, and should be so entered.

If the criteria are not met after skewing, take an additional 50 samples. The maximum to be taken at any one site is 250. If the criteria are still not met after 250 samples, note this at the bottom of the data sheet.

Even if the criteria are met after 100 samples, skewing should still be used if it will increase the accuracy of the results. For example, say the resulting limits for L_{10} after 100 samples without skewing are 75 +3 -3 dBA. Additionally, say that by skewing down, the limits would change to 75 +2 -3 dBA. The results should be reported as 75 +2 -3 dBA and skewing down indicated on the data sheet. If the accuracy can be increased through skewing, it should be done even if the criteria would be met without it.

4. When the test criteria have been met (or 250 samples taken and the criteria not met), calculate L_{50} and L_{90}. The former is the noise level exceeded 50 percent of the time and is represented by the 50th percentile reading from the top. Thus with 100 readings it's the 50th from the top, and so on. L_{90} is the noise level exceeded 90 percent of the time and is represented by the 90th percentile reading from the top. L_{90} for 100 readings is the 90th from the top; for 150 it is the 135th from the top.

   L_{50} is counted from the top. A common mistake is to count up from the bottom of the data to find L_{90}. For example, with 100 readings, counting up to the tenth reading from the bottom will give you the 91st from the top, not the 90th.

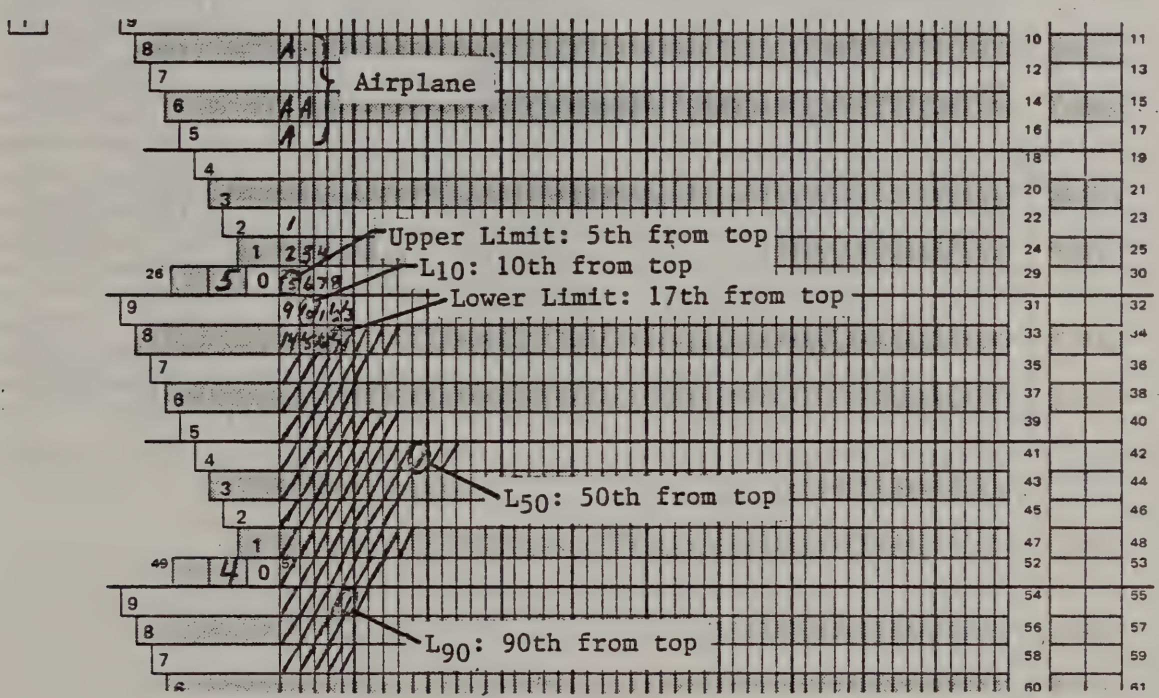
   A simple rule in finding L_{90} is to count up from the bottom of the data the same number of readings listed under L_{10} in the table, and then count up one more -- this is L_{90}. For instance,

for 150 readings, the table gives the 15th reading as L_{10}. To find L_{90}, count up from the bottom of the data 15 readings plus one.

The examples on this and the next two pages should help explain these rules.

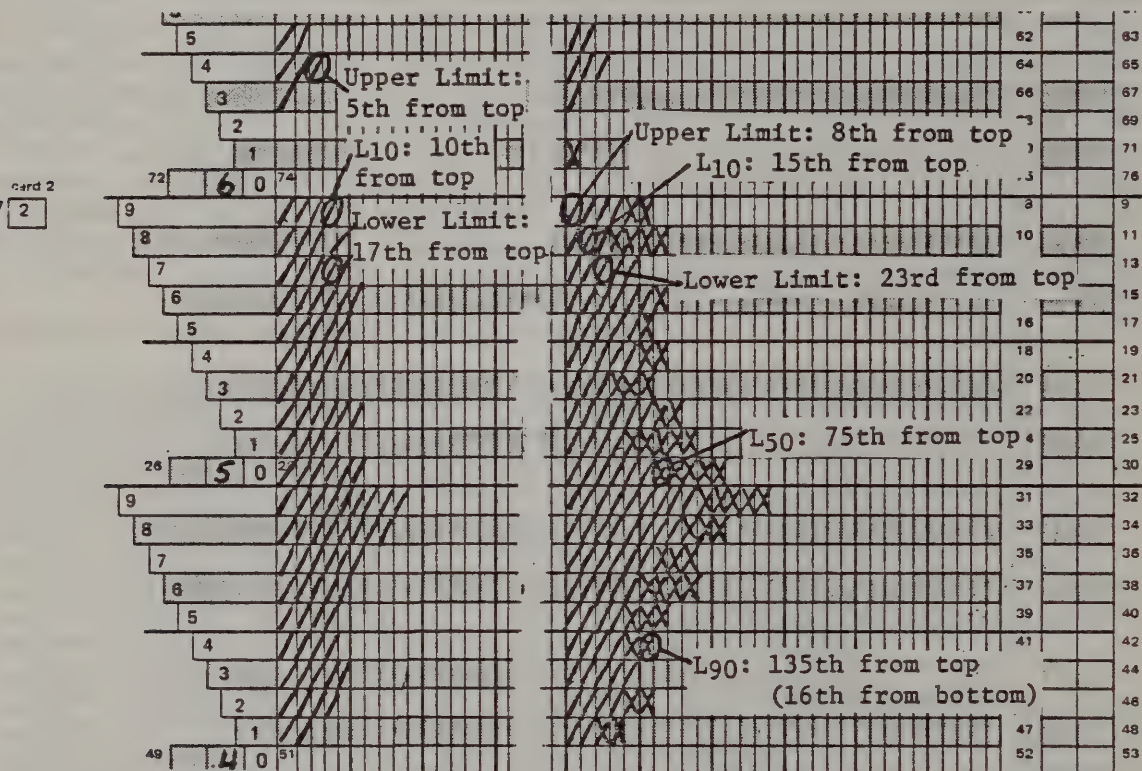
EXAMPLE 1 Criteria Met After 100 Samples

At this site, 100 readings were taken, ranging from 37 to 52 dB. (The four airplane readings, in this case, were not considered "representative" of the site and were not counted.) Counting down from the top, the highest reading is 52 dB the second and third both 51 dB, etc. as numbered on the sheet. In this case the tenth reading represents L_{10}, which is 49 dB. The fifth reading is the upper limit or 50 dB, and the seventeenth the lower limit at 48 dB. Since the difference between L_{10} (49 dB) and each limit is 1, L_{10} can be expressed as 49 ± 1. No further readings are necessary, as ± 1 is well within the ± 3 dB limits required. L_{50} is the 50th reading from the top at 44 dB and L_{90} the 90th at 39 dB.



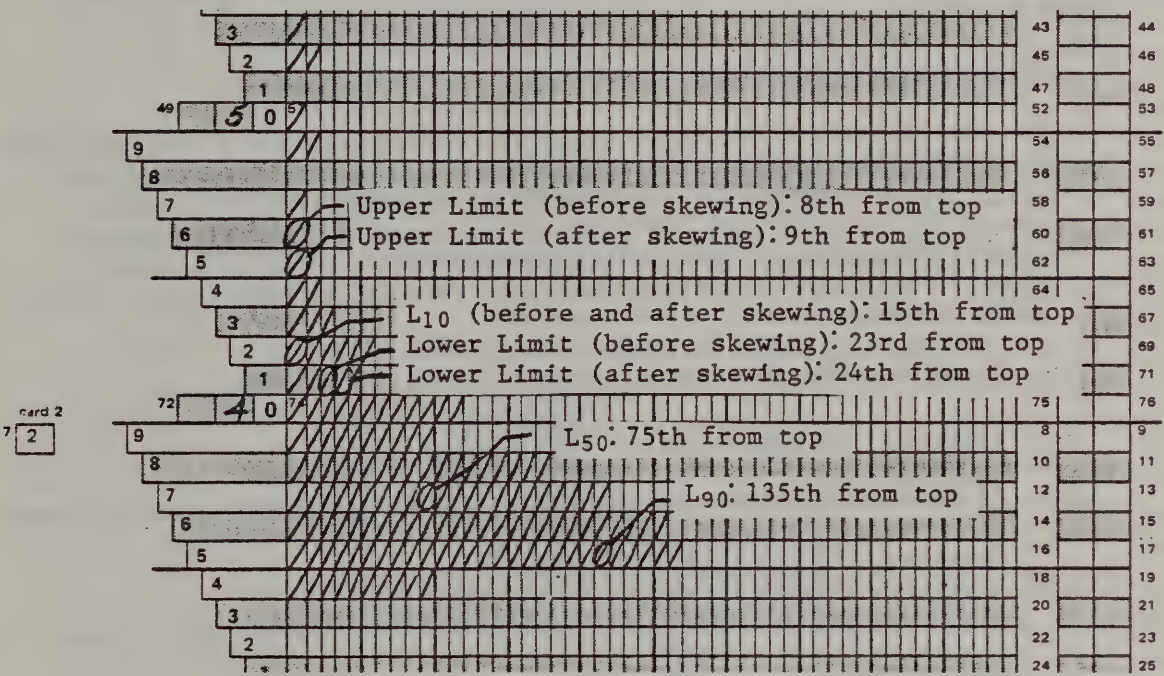
EXAMPLE 2 Criteria Not Met After 100 Samples; 50 More Were Taken

Here 150 samples were necessary. The first 100, represented by slashes, resulted in an L10 of 49 +5 -2 dB (54 being the upper limit, and 47 the lower), which is not within the limits of $\pm$ 3 dB. Even after skewing down, the limits would only be +4 -2. Fifty more readings were then taken and are represented by x's. The upper limit, L_{10}, and lower limit (the 8th, 15th, and 23rd readings) are now 49, 48, and 47 dB, respectively. The L_{10} limits (48 +1 -1 dB) are now within requirements.



EXAMPLE 3 Criteria Met After Skewing

In this case, 150 readings were taken. The upper limit, L_{10}, and lower limit are 46 dB (8th from the top), 42 dB (15th from the top), and 41 dB (23rd from the top). These data can be skewed down by shifting the upper limit to 9th from the top (44 dB), and the lower limit to 24th from the top (still 41 dB). L_{10} remains 42 dB and is now 42^{+3}_{-1} instead of 42^{+4}_{-1}.



5. Noise Data Forms

The form the NMT team will be concerned with when using the "check-off method" is the Noise Measurement Data Sheet (BR 320a). It contains information on the individual site location; a format for recording the actual test data; the coded tallies of data measurements; L_{10}, L_{50} and L_{90} values; and other information unique to a particular test and time. The BR 320a is the hard copy of the measurement data to support the EIS noise analysis.

a. General Rules for Coding Forms

Information must be written neatly and accurately. One character should be entered in each box provided. Use no special characters, roman numerals, or punctuation. Allowable characters include capital letters A through Z and the numbers 0 through 9. To differentiate between the leter O (oh) and the number 0 (zero), place a slash through the letter in this manner: Ø. The rules below give proper coding procedure.

1. Enter only one character (letter or number) in each box.

   13 Month 19 20 Day 21 22 Year 23

   Example: For May 8, 1976 05/08/76

2. Decimals are printed on the forms; print only numbers in the boxes.

   7 PIN 15

   Example: 4218.12.0000

3. Always record numbers from right to left in each group of boxes.

   Example: Enter a single digit as follows 006

4. If an error occurs, carefully erase the entry and place the correct data on both sheets of the form or draw a horizontal line through the entry, and record the correct data above the boxes involved.

   3040

   Example: ~~3004~~

5. If an item is incorrectly circled, draw a diagonal line through the error and circle the correct item.

   57 Day (Circle One)

   Example:

Sun 1	Mon 2	Tues 3	Wed 4	Thur 5	Fri 6	Sat 7

6. Record starting and finishing times in a 24-hour fashion.

   30 (24 Hour Clock) 33

   Example: For 3:45 p.m. 15:45

7. Enter a slash through the letter "O" to distinguish it from a zero.

   Example: SØUTH

b. Coding the Data Sheet (BR 320a)

   1. Record the meter serial number, cover sheet number, test interval, PIN, weight, response, precipitation, wind speed, relative humidity, temperature, and point number at the lower right of the form.

   2. Diagram the measurement site (including critical distances) at the lower left of the form.

   3. Indicate an acceptable initial battery check by placing a check (✓) in the box labeled "I."

   4. After calibrating the sound level meter, record the initial calibration values. (This should be 93.8 dB for the 2206 meter and 4230 calibrator.)

   5. Determine the general range of noise levels existing at the site and indicate this range on the data sheet in the boxes to the left of the check-off grid.

   6. Record the starting time and begin noise level measurements at the proper time interval. Indicate these readings on the check-off grid (see Data Recording and Reduction on p. 14).

   7. After completion of the noise measurements, record the time finished at the bottom of the sheet.

   8. Count up the check marks on the check-off grid and fill in the subtotals and total number of readings.

   9. Record the results of the final battery check and calibration. If these are within the specified limits, record L_{10}, the L_{10} limits, L_{50}, and L_{90} at the bottom of the form. (If the battery check and/or calibration value falls outside the specified limits, the equipment and, thus the data are questionable.)

   A typical example of a coded BR 320a is shown on the next page.

BR 320e (6/75)

NOISE MEASUREMENT DATA SHEET

card 1

7 [1]

decibel range	Subtotal
89	
88	
87	
86	
85	
84	
83	
82	
81	
80	
79	
78	
77	
76	
75	
74	
73	1
72	2
71	3
70	4
69	7
68	9
67	10
66	10
65	9
64	8
63	7
62	7
61	6
60	6

card 2

7 [2]

decibel range	Subtotal
59	5
58	3
57	2
56	1
55	
54	
53	
52	
51	
50	
49	
48	
47	
46	
45	
44	
43	
42	
41	
40	

Batt Check (√) I ☑ F ☑ — Initial Calib 1000 Hz ▶ 93.8 — Final Calib 1000 Hz ▶ 93.7 — Meter Serial Number ▶ 54 [213716] 59

Total 60 [100] 62

card 3

7 [3]

Diagram

8 Month 9: 07 / 10 Day 11: 28 / 12 Year 13: 75 — 14 Cover Sheet Number 19: 000502

Test Intvl(sec) 20 [10] 22 — 23 PIN 27 31: 1310·02·111

Weight 32 [A] — 33 Response (Circle): Fast F / Slow (S) — 34 Precip (Circle): No (N) / Yes Y — Wind (MPH) 35 [08] 36

% Rel. Humidty 37 [76] 39 — 40 Temp. (°F) [81] 42 — 43 Skew (Circle): None (0) / U↑ / D↓

44 Start (24 Hr. clock) 47: 13:35 — 48 L10 50: 70 — 51 [1] 52 [1] — 53 L50 54: 65

55 Finish (24 hr. clock) 58: 14:05 — 59 L90 60: 59 — 61 Point Number 63: A2

6. Special Considerations

General sites for noise measurements will usually be chosen and located on a map by a design or planning engineer. The technician team then takes the map to the sites and picks the best location to set up equipment. If the site of interest is near a house or school, place the meter in the yard where there is likely to be human activity. The object is to measure noise from all sources to which the occupant is normally exposed -- not just traffic noise. Therefore, the meter should not be set up next to the road, where traffic noise is dominant. Also avoid billboards, sides of buildings, and other large reflecting surfaces. Noise tends to be reflected back to the microphone, increasing the noise level. It is sometimes necessary, however, to locate near a reflective surface; this should be done if so specified by the RNLE.

Sometimes it is difficult to determine whether a sound is characteristic of a site. For example, an airplane may fly over during a measurement period. Perhaps only one flies over each day and you caught it, or perhaps they fly over frequently. In the former case, note the readings, but don't use them for calculating L_{10}. In the latter, count the airplane as typical noise. A tractor operating on a farm might be considered typical noise, but one should try to return to the site to measure when it is not operating. In any event, the fact that a tractor was operating should be noted on the cover sheet.

As for when to measure, we are limited to whenever the technician team gets to the site. It is impractical to try to hit each site when it is noisiest. Rush-hour traffic is not necessarily the noisiest condition -- heavy truck traffic may not appear until night-time. The best we can do is to project noise levels from measurements accompanied by traffic counts. The fine points of site selection, disturbances, and other measurement-related problems are often left to the discretion of the NMT team. In an unusual situation, however, the RNLE should be consulted to resolve the problem. Additional support may be obtained (calling collect, if necessary) from the Main Office Noise Unit in Albany; use the state tie-line access code or Area Code 518, and then dial 457-4285. This unit is also interested in your comments on special problems and their resolution.

7. Noise Measurement Technician's Checklist

a. Equipment

1. Sound level meter with microphone.

2. Calibrator.

3. Windscreen.

4. Wind velocity meter.

5. Extension cable.

6. Tripod.

7. Clipboard and counter.

8. Sling psychrometer.

9. Stopwatch.

10. Spare batteries.

11. Coding sheets (BR 320a).

b. Procedure

1. Check that the meter is operating before going into the field.

2. Measure and record wind speed -- do not take noise measurements if the wind is over 12 mph. Check relative humidity twice a day; discontinue operations if it exceeds 90 percent. Discontinue noise measurements if the temperature falls below 14 F or exceeds 122 F.

3. Check the meter battery.

4. Set up the meter, tripod, and extension cable.

5. Calibrate the meter -- 93.8 dB before measuring -- and re-check it after each site measured. Repeat the measurement if it is not registering in the proper range (i.e., between 93.3 and 94.3 dB.)

6. Take noise readings using A-weighting and slow response. Note starting time.

7. Calculate L_{10}, L_{50}, and L_{90}. Note finishing time.

8. Fill out the data sheet completely before leaving the site.

9. Have your partner check your calculations.

B. Method 2: Measuring Existing Noise Level by the db-306A Metrologger Method

1. Scope

This test method prescribes procedures for measurement of existing noise levels using the Metrosonics db-306A Metrologger Meter*. The db-306A Metrologger is a handheld sound level meter which contains a micro-processor programmed to calculate Leq. Lmax is also displayed.

2. Equipment

a. Equipment Required

1. db-306A Metrologger Meter with Type mk-301P Boom Microphone.
2. cl-302 Acoustical Calibrator.
3. ws-301 Windscreen.
4. Wind Velocity Meter.
5. Extension Cable. (Optional)
6. Tripod with mounting adaptor.
7. Clipboard and Counter.
8. Sling Psychrometer.
9. Spare Batteries.
10. db-306/db-306A Metrologger Data Sheet (BR 187).

b. Equipment Descriptions

1. db-306A Metrologger with Boom Microphone

This meter is a battery-operated acoustical computer used to determine SPL, Leq and Lmax in dBA. See the illustration on page 36. Its features and controls are as follows:

a. Power Switch (S5)

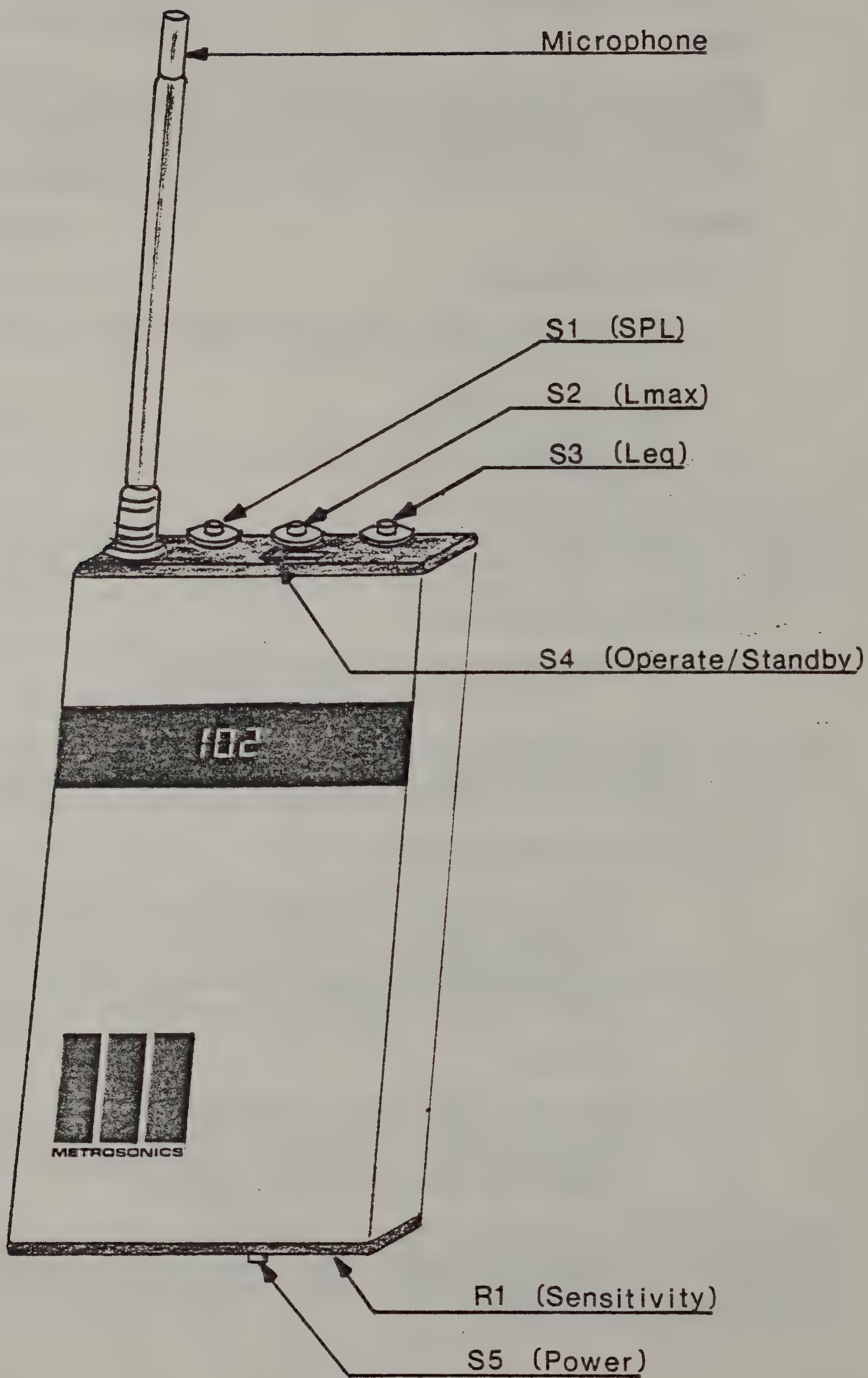
The power switch is located on the bottom of the meter and has two positions "on" and "off". A screw driver or ballpoint pen is needed to turn it "on" and "off" since it is a recessed button. Turning the power switch "off" for 3 seconds or more clears the internal data memories.

b. Display

The four digit liquid crystal display on the front of the meter displays the Leq, Lmax, SPL, and duration of the sampling period. When the battery life is less than 8 hours, "BATT" will appear upon the display.

*This test method may also be used with Metrologger Model db-306. The db-306 has a red LED display which becomes blank when pushbutton switches are released. Also, when battery life is low, decimal points will appear on the display rather than "BATT".

db-306A
Metrologger



c. SPL Switch (S1)

This spring loaded pushbutton switch when depressed displays the instantaneous SPL function in dBA. It is located next to the microphone boom.

d. Lmax Switch (S2)

This switch is located next to the SPL switch. When depressed it displays the Lmax value. This value is the maximum SPL within the sampling period.

e. Leq Switch (S3)

This switch is the third pushbutton switch on the top of the meter. When depressed it displays the Leq which is the integrated average SPL for the sampling period.

f. Time Display

This feature of the Metrologger allows the operator to determine the duration of the testing interval by depressing two switches simultaneously. If S1 and S3 are depressed, the hours and minutes are shown. If S1 and S2 are depressed, the minutes and seconds are shown. The latter is the only time display we will be concerned with since the maximum testing period is usually 25 minutes.

g. Operate/Standby Switch (S4)

This slide switch which is located on the top of the meter has two settings, "operate" and "standby". The "operate" position, which is toward the microphone, is used when collecting data. The "standby" position, which is away from the microphone, is used during calibration and microphone exchange to interrupt the acquistion of data.

h. Sensitivity Adjustment (R1)

This small screw on the bottom of the meter will adjust the display reading of the SPL when calibrating the meter.

i. Microphone

This ceramic microphone is mounted on a 4½ inch boom which is attached to the top of the meter.

2. Acoustical Calibrator

This is used to calibrate the sound level meter. The calibration signal for the cl-302 calibrator is 102dB at 1000 Hz.

3. Windscreen

   This foam ball when placed over the microphone reduces the noise caused by the wind blowing across the microphone. It is effective up to 12 mph, at which speed measurements are to be discontinued. Always use the windscreen, even on still days, since it also protects the microphone from dust and damage.

4. Wind Velocity Meter

   Instructions for use are printed on the back of this meter: "To use, face the wind. Hold meter in front of you in vertical position and with scale side toward you. Do not block bottom holes. Height of ball indicates wind velocity. For high scale, cover hole at extreme top with finger." Take wind velocity readings at the beginning of each measurement period.

5. Extension Cable

   The cable is used only in rare cases when two simultaneous readings are needed or if, for practical reasons, the microphone must be placed away from the meter. The cable attaches to the microphone boom at one end and the meter at the other.

6. Tripod with Mounting Adaptor

   Used to support the microphone or microphone and meter about 5 feet above the ground.

7. Clipboard and Counter

   A legal-size clipboard is supplied with a counter attached. The counter can be used to keep a vehicle count.

8. Sling Psychrometer

   Noise should not be measured when the relative humidity rises above 90 percent. Higher humidity often causes condensation on the microphone, rendering it useless until it dries. The psychrometer thus is used to determine relative humidity. The manufacturer's operating instructions are reproduced on page 22. Measure relative humidity twice daily, usually in the morning and the afternoon.

c. Calibration of the db-306A Metrologger

As was mentioned previously, the cl-302 calibrator has a calibration signal of 102dB at 1000Hz. The calibration procedure is as follows:

1. Slide the S4 switch to "standby".

2. Turn on the meter power switch, S5.

3. Depress S1. The SPL will be displayed.

4. Place the calibrator on the microphone, seat it firmly, and turn it on. The display should indicate 102dB. If it does not, turn the sensitivity adjustment screw on the bottom of the meter until the display shows 102dB. Note that the operating temperature range for this instrument is -10°C (14°F) to 50°C (122°F). Near either extreme, the meter may drift slightly from 102dB. If this is the case, turn the calibrator and meter off. Wait a few minutes for the meter to become acclimated to the ambient temperature and then calibrate the meter.

5. Once the meter has been calibrated turn the calibrator off and carefully remove it from the microphone. Attach the windscreen immediately.

6. If the calibrator isn't functioning properly, replace the calibrator battery as follows:

   a. Remove the plate on the base of the calibrator.

   b. Carefully disconnect the wires from the old battery.

   c. Carefully connect the new battery and place it in the calibrator.

   d. Replace the plate.

d. Battery Replacement for the db-306A Metrologger

In the normal operating mode of the db-306A, if the symbol "BATT" appears on the display, the remaining battery life is 8 hours or less. When this occurs, or if the display is totally blank, replace the battery with an MN-1604D 9-volt battery or a standard NEMA 1604 or 1604D 9-volt battery. (An MN-1604D gives the maximum operating life.)

To replace the battery:

1. Turn the meter off by depressing S5.

2. Remove the large screw at the bottom of the meter.

3. Remove the bottom plate, exposing the battery.

4. Replace the battery, bottom plate and screw.

5. Turn the meter on by depressing S5 and check the display. When S1 is depressed, the SPL should be displayed and the symbol "BATT" should no longer be seen.

e. Maintenance and Repairs

The db-306A Metrologger, microphone and calibrator are precision equipment and should be treated accordingly. If they fail to operate properly, return them to the Noise Measurement Unit of the Materials Bureau at the Albany Main Office, either by courier (if available) or by United Parcel Service. (Do not send by parcel post.) When shipped to the region from Albany, the equipment is accompanied by a receipt; check to be sure all that is supposed to be shipped is actually included in the package. When the equipment is returned to Albany, return the receipt, and note if any equipment was lost or broken. Keep each set of equipment together - don't mix and match with other sets, as that makes it more difficult to keep track of equipment.

3. Test Procedure

The method used to determine Leq and Lmax is very simple because the db-306A contains an internal microprocessor which performs all computations. The meter collects 4 samples/second and the Leq value is continuously updated. The data, Leq and Lmax, appears as digital readout on the display. The computational accuracy of the meter is ± .5dB. The procedure is as follows:

a. Check the equipment for proper operation before going into the field. The following checks should be performed.

   1. Battery. With the microphone attached and switch S4 on "standby" turn the meter on by depressing switch S5. Depress the SPL button, S1. If there is no display or if "BATT" appears on the readout, replace the battery using the procedure described in Section 2d.

   2. Calibration. Verify that the equipment can be properly calibrated as described in Section 2c.

   3. Data Collection. With S4 on "standby", check that the time display functions indicate zero and that they are not updating. Also, check the Lmax and Leq display functions: these should indicate the base value of 40. Switch S4 to "operate". Check that the time display functions are now updating and that Lmax and Leq are above the base value and updating.

   After confirming the proper operation of the equipment, place S4 on "standby" and turn the meter off by depressing switch S5. Remove the microphone and place the meter, microphone and calibration equipment back in the carrying case. If the equipment cannot be made to operate properly, refer to Section 2e above.

b. At the measurement site, obtain weather data (wind velocity, relative humidity, temperature, precipitation), and record this information on the data sheet as described in Section 4. The db-306A's operating temperature range is from -10°C (14°F) to 50°C (122°F). Discontinue operations if the ambient temperature is outside this range, if the

relative humidity exceeds 90 percent, if the wind velocity is greater than 12 mph or during precipitation.

c. Remove the meter from the carrying case and attach the microphone.

d. Check the battery as described above.

e. Set up the tripod with the mounting adapter. Insert the meter and microphone into the adapter. (If an extension cable is used, only the microphone will be attached to the tripod.)

f. Calibrate the meter as described in Section 2c.

g. Attach the windscreen.

h. Note the time and slide S4 towards the microphone to "operate".

i. At intervals of 5, 10, and 15 minutes read Lmax (depress S2) and Leq (depress S3). Record them on the data sheet. While taking the readings note the sources of the noise (i.e. local traffic, expressway, etc.). Also note any unusual disturbance or condition i.e. horn, helicopter, airplane, truck, reverberation off of a building etc. These factors should be noted on the data sheet.

<u>Special Note</u>:

An unusual noise occurrence which is not a part of the normal ambience can be excluded from the data collected by switching S4 to "standby" until the occurrence has passed and then returning S4 to "operate". None of the data collected before S4 is switched to "standby" will be lost, the data registers and time functions will be frozen until S4 is placed on "operate". After placing S4 on "operate", continue to record Lmax and Leq at 5-minute intervals as indicated by the time display.

j. Simultaneously keep count of the numbers of cars and trucks passing the measurement site if the location is close to or within sight of a roadway.

k. If Leq has stabilized to the same value at the 10 and 15 minute readings, stop. If not, continue to take readings at 5-minute intervals until two consecutive Leq readings are the same. (Discontinue after 25 minutes.)

<u>Special Situation</u>:

If you should notice that your Leq values are flucuating between two numbers, depress the S3 switch and note the Leq values. Do they fluctuate between, for example, 69 and 70? If they do, the final Leq value should be recorded as 69.5. Because the meter only displays integers, it is constantly rounding off to the closest integer. The actual Leq value is probably somewhere between 69.4 and 69.6. The

meter, however, continues to round either up to 70 or down to 69. This is the only situation in which you need to record a decimal point on the data sheet. All other data should be in whole numbers.

l. After reaching a stable Leq (i.e. two consecutive identical Leq values), switch S4 to "standby" and then record Leq and Lmax at the bottom of the data sheet. Also record L10 which is computed by adding 3 to Leq.

m. At the conclusion of the test, recheck the calibration of the meter, recheck the battery and record these results on the data form. Also include a diagram of the location with critical distances.

n. Note the time finished and record it on the data sheet. Recheck to be sure the data form is complete and accurate.

o. Turn the meter off using switch S5. (This will clear the data memory where Lmax and Leq are stored.)

p. To perform an accurate analysis, it is imperative that at least two sets of data be taken at each site. If possible these measurements should be taken at different times of the day, noting special factors which contribute to the ambient noise level such as peak traffic volumes, manufacturing operations, etc. If the difference in the Leq of the two sets of data is less than or equal to 3dBA, a third set of data is not needed. If, however, the difference is greater than 3dBA, a third set of data should be taken and factors causing these level flucuations should be noted.

4. <u>Noise Data Form</u>

Data collected using the db-306A should be recorded on the db-306/db-306A Metrologger Data Sheet (BR 187). See the illustration on page 43.

The general rules for coding forms can be found on pages 30-31.

The db-306/db-306A Metrologger Data Sheet (BR 187) is coded as follows:

1. Record the meter serial number, date, coversheet number, PIN, precipitation, windspeed, relative humidity, temperature and point number at the bottom of the form.

2. Diagram the measurement site (including critical distances) at the lower left of the form.

3. Indicate an acceptable initial battery check by placing a check (✓) in the box labeled "I".

4. After calibrating the db-306A, record the initial calibration value. (This should be 102dB for the db-306A Metrologger when calibrating with the cl-302 Acoustical Calibrator.)

5. Record the starting time and the noise level measurements at the

BR 187 (7/84)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

db-306/db-306A METROLOGGER DATA SHEET

TIME INTERVAL	Lmax	Leq	COMMENTS/SOURCES:
5 min.			
10 min.			
15 min.			
20 min.			
25 min.			

Batt Check ► (✓) I ☐ F ☐ | Initial Calib ► 1000 Hz __ __ __ | Final Calib ► 1000 Hz __ __ __ | Meter Serial ► Number

Month / Day / Year

Cover Sheet Number

PIN

% Rel. Humidity | Temp. (°F) | Precip (Circle) No N Yes Y | Wind (MPH)

Start (24 Hr. clock) : | Lmax | Leq .

Finish (24 Hr. clock) : | L10 .

Point Number

DIAGRAM

proper time intervals. Also note noise sources and any unusual noises. If possible note the intervals in which they occur.

6. After completion of the noise measurements, record the time finished and the final Leq, Lmax, and L10 values.

7. Record the results of the final battery check and calibration. (If the battery check and/or calibration value falls outside the specified limits, the equipment and the data are questionable.)

5. Special Considerations

General sites for noise measurements will usually be chosen and located on a map by a design or planning engineer. The technician then takes the map to the sites and picks the best location to set up equipment. If the site of interest is near a house or school, place the meter in the yard where there is likely to be human activity. The object is to measure noise from all sources to which the occupant is normally exposed - not just traffic noise. Therefore, the meter should not be set up next to the road, where traffic noise is dominant. Also avoid billboards, sides of buildings, and other large reflecting surfaces. Noise tends to be reflected back to the microphone, increasing the noise level. It is sometimes necessary, however, to locate near a reflective surface; this should be done if so specified by the RNLE.

Sometimes it's difficult to determine whether a sound is characteristic of a site. For example, an airplane may fly over during a measurement period. Perhaps only one flies over each day and you caught it, or perhaps they fly over frequently. If the former is true record the data but note in the comments section the fact that an airplane flew over during that time interval. This data is questionable and probably shouldn't be in the final Leq or Lmax value. If it's known that the sound is not typical of the site you should stop taking readings and resume after the disturbance is over. This can be done by switching S4 to "standby" and later switching it back to "operate." Once the meter is again on "operate" it will resume taking readings and the meter's clock will resume counting the test duration. If, however, you should decide to discard the data collected and start again, turn the S4 switch to "standby" and turn the power switch off. Leave the meter off for 3 seconds to clear it. Turn the power switch back on, note the time and switch S4 to "operate" to start the new test. If the noise from the airplane is typical of the site note it on the comments section and record the data.

As for when to measure, we are limited to whenever the technician team gets to the site. It is impractical to try to hit each site when it is noisiest. Rush-hour traffic is not necessarily the noisiest condition - heavy truck traffic may not appear until night-time. The best we can do is to project noise levels from measurements accompanied by traffic counts. The fine points of site selection, disturbances and other measurement-related problems are often left to the discretion of the NMT team. In an unusual situation, however, the RNLE should be consulted to resolve the problem. Additional support may be obtained (calling collect, if necessary) from the Main Office Noise Unit in Albany; use the

State tie-line access code or Area Code 518 and then dial 457-4285. This unit is also interested in your comments on special problems and their resolution.

6. Noise Measurement Technician's Checklist

a. Equipment

1. db-306A Metrologger with boom microphone.

2. cl-302 Acoustical Calibrator.

3. Windscreen.

4. Wind Velocity Meter.

5. Extension Cable. (Optional)

6. Tripod with Mounting Adaptor.

7. Clipboard and Counter.

8. Sling Psychrometer.

9. Spare Batteries.

10. db-306/db-306A Metrologger Data Sheets (BR 187a).

b. Procedure

1. Check that the meter is operating before going into the field.

2. Measure and record windspeed - do not take noise measurements if the wind is over 12 mph. Check relative humidity twice a day; discontinue operations if it exceeds 90 percent or during precipitation. Avoid noise measurements if the temperature falls below 14°F.

3. Check the meter battery.

4. Set up the meter tripod and extension cable if necessary.

5. Calibrate the meter - 102 dBA before measuring - and recheck it after each site measured. Repeat the measurements if the final calibration value is not 102dBA.

6. Note the starting time. Record Lmax and Leq every 5 minutes. If Leq has stabilized for the 10 and 15 minute readings, stop. If not, continue until two consecutive readings are the same. Discontinue at 25 minutes.

7. Note finishing time. Record the final L10, Leq and Lmax at the bottom of data sheet.

8. Fill out the data sheet completely before leaving the site.

References

1. U.S. Department of Transportation, Federal Highway Administration. Fundamentals and Abatement of Highway Traffic Noise, September 1980, Document 2, pp. 72-76.

APPENDIX

A. Glossary of Terms
B. Forms List
C. Equipment List
D. Method of Determination of Confidence Limits and Coefficients
E. References for Further Reading
F. Mathematical Statement of Sound Pressure Level and Decibel Addition of Two Equal Sources
G. Federal-Aid Highway Program Manual 7-7-3
H. Interim Project Development Guidelines: Transmittal 17
I. Noise Impact Evaluation Model

A. Glossary of Terms

A-Weighting: adjustment of the amplitude of a sound wave based on frequency designed to approximate frequency response of the human ear.

Ambient Noise: all noise existing at a site.

Amplitude: for a wave, the amount of displacement from an equilibrium level.

Attenuation: a reduction of wave amplitude.

Calibrator: an electronic device used to generate a known sound level.

Car: any four-tire, two-axle vehicle, including sports cars, pickup trucks, and small vans.

Characteristic Sound: a sound representative of a measurement site.

Check-off Method: a method for measuring ambient noise by taking readings at a prescribed time interval, ranking them, and analyzing them statistically.

Confidence Limits: the upper and lower values of the range within which a given percent probability applies; for instance, if the chances are 95 out of 100 that a sample lies between 10 and 12, the 95-percent confidence limits are said to be 10 and 12.

Cycle per Second: a complete wave occurring in 1 second (see Hertz).

Data: measurements taken as bases for an investigation.

dB: abbreviation for decibel.

dBA: abbreviation for decibel utilizing the A-weighting network.

Decibel: the units of amplitude measurement for sound pressure level, defined as

$$SPL_{dB} = 10 \log \left(\frac{P}{P_0}\right)^2 \quad \text{or} \quad SPL_{dB} = 20 \log \left(\frac{P}{P_0}\right)$$

where P = disturbance pressure, and

P_0 = reference pressure.

Equilibrium Level: the reference or undisturbed level for a particular quantity; for sound, the equilibrium level is atmospheric pressure.

Frequency: the number of time a wave repeats within a given period.

Heavy Truck: any three or more axle vehicle including commercial busses.

Hertz: one cycle per second, abbreviated Hz.

Humidity: the percent of moisture in the air.

L_{10}, L_{50}, L_{90}: sound levels exceeded, respectively, 10, 50, and 90 percent of the time.

Leq: the integrated average SPL for the sampling period.

Logarithm: the power to which a base number is raised to equal a given value; for example, $_{10}2$ = 100 and $\log_{10}$ 100 = 2.

Masking: the effect whereby a sound that is approximately 10 dB or greater than another "drowns out" the lesser sound.

Medium Truck: any two-axle, six-tire vehicle or motorcycle.

Microphone: an electronic device sensitive to pressure changes, converting them into electrical current.

Noise: unwanted sound.

Pressure: force applied on a given area; some pressure units are pounds per square inch (psi), atmospheres, etc.

Reference Pressure: for sound measurement, this is 20 micornewtons per square meter; -- the smallest pressure the ear can detect.

Sling Psychrometer: a device for measuring relative humidity.

Sound: a wave disturbance in an elastic medium, such as air.

Sound Level: weighted sound pressure level measured by a metering device.

Sound Level Meter: a device for measuring sound level.

Sound Pressure Level: in decibels, 10 times the logarithm of the square of the ratio of the disturbance pressure to the reference pressure; it is a measure of the amplitude of a sound wave.

Traffic Mix: percentage of cars and trucks in the total number of vehicles.

Traffic Volume: total number of vehicles in a given time period.

Wave: variation in a medium characterized by frequency and amplitude.

Windscreen: a porous polyurethane sponge material used on a microphone to eliminate wind noise and protect against dust.

Wind Velocity Meter: a device for measuring wind speed.

B. Forms List

1. Form BR 320a: Noise Measurement Data Sheet.
2. Form BR 187a: db-306/db-306A Metrologger Data Sheet.

C. Equipment List

1. a. Brüel and Kjaer Type 2206 Sound Level Meter with Type 4148 Condenser Microphone. Brüel and Kjaer Type 4230 Calibrator.

   or

   b. Metrosonics db-306A Metrologger with Type mk-301P Boom Microphone. Metrosonics Type cl-302 Calibrator.
2. Windscreen.
3. Wind Velocity Meter.
4. Extension Cable. (Optional)
5. Tripod.
6. Clipboard with counter.
7. Sling Psychrometer.
8. Stopwatch. (with B&K 2206 only)

D. Method of Determination of Confidence Limits and Coefficients

This method is reproduced in facsimile from Fundamentals and Abatement of Highway Traffic Noise (see Anderson, Miller, and Shadley in Appendix E).

Assume that a total of n statistically independent noise levels l have been measured from the same population. Assume, further, that these noise levels are ordered according to their magnitudes, and let the sequence of these ordered levels be denoted by l_1, $l_2, \ldots l_n$, where the highest measured level is denoted by l_1 and the lowest is denoted by l_n.

Let L_p denote the p*th* percentile noise level as determined by the infinite population from which the n samples have been drawn. L_p is defined by,

$$\int_{L_p}^{\infty} f(l)\,dl = p, \qquad (1)$$

where $f(l)$ is the probability density function of the noise levels from which the samples have been drawn. Thus, the probability is p that a randomly drawn sample will have a level l higher than the level L_p. The problem is to estimate L_p, for a given value of p, from a finite set of ordered samples l_1, $l_2, \ldots, l_n$.

Assume that n samples have been drawn and ordered as described above. Consider the event $l_r > L_p > l_s$ where $r<s$; that is, the event that the r*th* noise level is higher than L_p and the s*th* noise level is lower than L_p. This event is equivalent to the compound event that exactly r measured levels are higher than L_p *or* exactly r+1 measured levels are higher than L_p *or* ... *or* exactly s-2 measured levels are higher than L_p *or* exactly s-1 mea-

sured levels are higher than L_p. These events are mutually exclusive; therefore, the probability of this compound event is the sum of the probabilities of the individual events. Now, according to Eq. 1, the probability is p that any one noise level measurement is larger than L_p. Since the measured levels are assumed statistically independent, the probability that exactly k of the measured levels are higher than L_p is the probability of exactly k "successes" in a set of n Bernoulli trials, where the probability of the "success" of a single trial is p. In such a situation, the probability of k successes is

$$\binom{n}{k} p^k (1-p)^{n-k} , \tag{2}$$

where

$$\binom{n}{k} = \frac{n!}{(n-k)!k!} . \tag{3}$$

Thus, the probability of the above described compound event is obtained by summing the probabilities (2) for k=r, r+1, ..., s-2, s-1; that is

$$Pr\left[l_r > L_p > l_s\right] = \sum_{k=r}^{s-1} \binom{n}{k} p^k (1-p)^{n-k} \tag{4}$$

Equation 4 expresses the probability that at least r but less than s noise level measurements fall above the level L_p. Notice that at no point have we made any assumptions about the form of the noise level probability density function $f(l)$.

Let us now designate $Pr\left[l_r > L_p > l_s\right]$ by γ; i.e.,

$$Pr\left[l_r > L_p > l_s\right] = \gamma . \tag{5}$$

Then, by definition, γ is the confidence coefficient that the *rth* and *sth* measured levels satisfy the relationship $l_r > L_p > l_s$; l_r and l_s are known as the upper and lower confidence limits for the *pth* percentile noise level L_p.

Table 3.1 lists values of γ for selected sets of values of n, r, and s, where all values listed are for the case where $p = 0.10$. The values were computed using the right-hand side of Eq. 4.

TABLE 3.1 - CONFIDENCE COEFFICIENTS

Number of Samples, n	Lower Error Limit, r	Upper Error Limit, s	Confidence Coefficient, γ
350	24	46	0.949
350	25	47	0.950
350	26	48	0.944
300	19	40	0.952
300	20	41	0.957
300	21	42	0.955
250	15	34	0.950
250	16	35	0.956
250	17	36	0.952
200	11	28	0.949
200	12	29	0.956
200	13	30	0.952
150	7	22	0.950
150	8	23	0.960
150	9	24	0.955
100	4	16	0.952
100	5	17	0.956
100	6	18	0.932
50	1	10	0.970
50	2	10	0.942

E. References for Further Reading

1. Books on Noise, Acoustics, and Related Problems

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F. Mathematical Statement of Sound Pressure Level And Decibel Addition of Two Equal Sources

The mathematical statement of sound pressure level in decibels is

$$SPL_{dB} = 20 \log_{10} \frac{P}{P_0}$$

where P = the change from atmospheric pressure caused by the sound wave, and

P_0 = the reference pressure, equal to the smallest pressure the human ear can detect.

As stated earlier, the range of pressures the human ear can detect is very large. Because this is true, the logarithm of the pressure ratio is used. By using a logarithm, we can convert a very large number into a much smaller one. We can then convert the very large range of pressures the human ear can detect into a smaller range of numbers that are easier to deal with, thus making it easier to compare different sounds.

For instance, suppose we had four sound waves, each causing a pressure disturbance 10 times greater than the previous one. In mathematical terms, we could state this as follows:

Sound Wave 1: $P_1 = 100\ P_0$

Sound Wave 2: $P_2 = 10\ P_1 = 1{,}000\ P_0$

Sound Wave 3: $P_3 = 10\ P_2 = 10{,}000\ P_0$

Sound Wave 4: $P_4 = 10\ P_3 = 100{,}000\ P_0$

Dividing both sides of these equations by P_0, we get:

$$\frac{P_1}{P_0} = 100 \frac{P_0}{P_0} = 100$$

$$\frac{P_2}{P_0} = 1000 \frac{P_0}{P_0} = 1{,}000$$

$$\frac{P_3}{P_0} = 10{,}000 \frac{P_0}{P_0} = 10{,}000$$

$$\frac{P_4}{P_0} = 100{,}000 \frac{P_0}{P_0} = 100{,}000$$

since dividing P_0 by P_0 is equal to 1, just as 2 divided by 2, or 3 divided by 3 equals 1.

Now, SPL is defined in terms of "base 10" logarithms. This means we know that 10 x 10 = 100 -- 10 x 10 is known as 10^2 (10 squared). Similarly, 10 x 10 x 10 = 1,000 = 10^3 (10 cubed). The "base 10" logarithm of a number is defined as the number of times 10 must be multiplied by itself to get the number. For instance,

$$10 \times 10 = 100$$

or

$$10^2 = 100$$

Then

$$\log_{10} 100 = 2$$

Ten multiplied by itself will give 100. Therefore, the base 10 logarithm of 100 is equal to 2. In the same way, then, if $\log_{10} 100 = 2$, then

$$\log_{10} 1{,}000 = 3 \quad (10 \times 10 \times 10 = 1000)$$

Similarly,

$$\log_{10} 10{,}000 = 4 \quad (\underset{1}{10} \times \underset{2}{10} \times \underset{3}{10} \times \underset{4}{10} = 10{,}000)$$

$$\log_{10} 100{,}000 = 5 \quad (\underset{1}{10} \times \underset{2}{10} \times \underset{3}{10} \times \underset{4}{10} \times \underset{5}{10} = 100{,}000)$$

Let's return to our sound waves. The SPL equation says we multiply 20 times the base 10 logarithm of P/P_0. Setting up a table:

Sound Wave	P/P_0	$\log_{10} P/P_0$	SPL_{db}
1	100	2	40
2	1,000	3	60
3	10,000	4	80
4	100,000	5	100

We can see that for a range of pressures from 100 to 100,000 times the smallest pressure the ear can detect, the range in decibels is only 40 to 100. It is much easier to compare numbers from 40 to 100, and plot 40 to 100 on a graph or measuring device, than to plot 100 to 100,000.

Now, as we also said earlier, if two boards are each 10 ft long, the total length of both is 20 ft. However, two equal sound sources producing 70 dB each add up to only 73 dB -- not 140 dB. This is because:

the definition of SPL is decibels is:

$$SPL_{dB} = 20 \log_{10} \frac{P}{P_0}$$

this is the same as

$$SPL_{dB} = 10 \log_{10} \left(\frac{P}{P_0}\right)^2$$

where

$$\left(\frac{P}{P_0}\right)^2 = \frac{P}{P_0} \times \frac{P}{P_0}$$

To prove this, let's assume $P/P_0 = 100$. Then

$$\left(\frac{P}{P_0}\right)^2 = \frac{P}{P_0} \times \frac{P}{P_0} = 100 \times 100 = 10{,}000$$

Lets put the two equations for SPL side by side:

$SPL_{dB} = 20 \log_{10} \frac{P}{P_0}$	$SPL_{dB} = 10 \log_{10} \left(\frac{P}{P_0}\right)^2$
$SPL_{dB} = 20 \log_{10} 100$	$SPL_{dB} = 10 \log_{10} 10{,}000$
$\log_{10} 100 = 2$	$\log_{10} 10{,}000 = 4$
$10 \times 10 = 100$	$10 \times 10 \times 10 \times 10 = 10{,}000$
$\therefore SPL_{dB} = 20 \times 2$	$\therefore SPL_{dB} = 10 \times 4$
$SPL_{dB} = 40$	$SPL_{dB} = 40$

We can see then that both definitions are the same because they produce the same answer. Let's get back now to our two equal sound sources. Suppose the pressure ratio produced by one source is $(P/P_0) = 10$. Then

$$\left(\frac{P}{P_0}\right)^2 = \frac{P}{P_0} \times \frac{P}{P_0}$$

$$= 10 \times 10$$

$$= 100$$

For two equal sources, the pressure ratio squared will be twice this, or

$$2\left(\frac{P}{P_0}\right)^2 = 200$$

$$SPL_{\text{one source}} = 10 \log_{10} \left(\frac{P}{P_0}\right)^2$$

$$\left(\frac{P}{P_0}\right)^2 = 100$$

$$SPL_{\text{one source}} = 10 \log_{10} 100$$

$$\log_{10} = 2$$

$$\therefore SPL_{\text{one source}} = 10 \times 2$$

$$SPL_{\text{one source}} = 20 \text{ dB}$$

$$SPL_{\text{two equal sources}} = 10 \log_{10} 2\left(\frac{P}{P_0}\right)^2$$

$$2\left(\frac{P}{P_0}\right)^2 = 200$$

$$SPL_{\text{two equal sources}} = 10 \log_{10} 200$$

$$\log_{10} 200 = 2.3$$

(The base 10 log of 200 can be found in any table of logarithms)

$$\therefore SPL_{\text{two equal sources}} = 10 \times 2.3$$

$$SPL_{\text{two equal sources}} = 23 \text{ dB}$$

Thus two equal sources produce only a 3-dB increase in SPL over only one of the sources.

G. Federal-Aid Highway Program Manual 7-7-3

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
WASHINGTON, D.C. 20590

FEDERAL-AID HIGHWAY PROGRAM MANUAL

TRANSMITTAL 192
May 14, 1976
HEV-21

1. MATERIAL TRANSMITTED

   a. Volume 7, Right-of-Way and Environment; Chapter 7, Environment; Section 3, Procedures for Abatement of Highway Traffic Noise and Construction Noise.

   b. Table of Contents for Volume 7, Chapter 7.

2. EXISTING ISSUANCES AFFECTED

   a. PPM 90-2, Noise Standards and Procedures (Federal-Aid Highway Program Manual (FHPM), Volume 7, Chapter 7, Section 3), dated February 8, 1973, is superseded.

   b. FHPM, Volume 7, Chapter 7, Section 3, Subsection 1 is superseded.

3. COMMENTS

   This directive was developed pursuant to Section 109(i) of Title 23, U.S.C. It is primarily a consolidation of two existing directives, PPM 90-2 and FHPM 7-7-3-1. In addition to rewriting the noise standards in the FHPM format, the language has been changed in some sections to more clearly indicate the intent of the directive. The following significant additions have also been made:

   a. Exceptions to the design noise levels are no longer required on highway projects on which the access is uncontrolled.

   b. The original directive (PPM 90-2) stated that if a project had location approval prior to July 1, 1972, and design approval prior to July 1, 1974, then compliance with the noise standards was not a prerequisite to PS&E approval. The new directive requires compliance with the noise standards for all projects which receive authorization to advertise for the major grade and drain elements after July 1, 1976.

c. An additional optional noise descriptor (L_{eq}) is included in the directive. The new descriptor is more statistically reliable for low volume roadways. It is also more flexible in terms of permitting noise levels from different sources to be included in the analysis.

d. The directive requires some general steps concerning construction noise. These steps include identifying sensitive land uses or activities during the project development studies, determining the measures needed to minimize or eliminate the adverse construction noise impacts, and incorporating the needed abatement measures in the contract documents.

e. The funding policy is expanded to permit the Regional Federal Highway Administrator to approve on a case-by-case basis extraordinary noise abatement measures where the noise impacts are especially severe and where ordinary kinds of abatement measures are physically infeasible or economically unreasonable. These extraordinary measures could include the acquisition of a severely impacted property, the relocation of a dwelling or structure or the noise insulation of a private dwelling.

4. REGULATORY MATERIAL

This entire directive will be regulatory and will be published in the Federal Register under 23 CFR Part 772.

5. EFFECTIVE DATE

This directive is effective May 24, 1976.

6. FILING INSTRUCTIONS

a. Page Changes

Remove	Insert
i of Table of Contents for Vol. 7, Ch. 7, dated 12/30/74	i of Table of Contents for Vol. 7, Ch. 7
1 thru 4 and Appendices A and B of PPM 90-2 dated 2/2/73	1 thru 22 of Vol. 7, Ch. 7, Sec. 3
1 and 2 of Vol. 7, Ch. 7, Sec. 3, Subsec. 1 dated 2/20/74	

b. Transmittal Changes. After filing the attached pages, this transmittal is to be filed behind the tab identified as "Transmittal Changes."

for Norbert T. Tiemann
Federal Highway Administrator

Distribution:
Basic

CHAPTER 7. ENVIRONMENT

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

FEDERAL-AID HIGHWAY PROGRAM MANUAL

VOLUME	7	RIGHT-OF-WAY AND ENVIRONMENT
CHAPTER	7	ENVIRONMENT
SECTION	3	PROCEDURES FOR ABATEMENT OF HIGHWAY TRAFFIC NOISE AND CONSTRUCTION NOISE

Transmittal 192
May 14, 1976
HEV-21

1. PURPOSE

* *To promulgate:*

a. policies and procedures for noise studies and noise abatement measures,

b. design noise levels, and

c. requirements for coordination with local officials for use in the planning and design of highways approved pursuant to Title 23, United States Code.

2. AUTHORITY

23 U.S.C. 109(h), 109(i), and 42 U.S.C. 4331, 4332.

*Regulatory material is italicized.

3. NOISE STANDARDS

The highway traffic noise studies, noise abatement procedures, coordination requirements, and design noise levels in this directive constitute the noise standards mandated by 23 U.S.C. 109(i). All highway projects which are developed in conformance with this directive shall be deemed in conformance with the FHWA noise standards.

4. DEFINITIONS (as used in this directive)

a. *Buffer Zone - lands, properties, and parcels (or portions thereof) adjacent to a highway acquired either in fee or a lesser interest for the purpose of preempting development which would be adversely impacted by traffic noise and for other noise abatement purposes.*

b. *Control of Access - the condition where the right of owners or occupants of abutting land or other persons to access, light, air, or view in connection with a highway is fully or partially controlled by public authority.*

(1) *Full control of access means that the authority to control access is exercised to give preference to through traffic by providing access connections with selected public roads only and by prohibiting crossings at grade or direct private driveway connections.*

(2) *Partial control of access means that the authority to control access is exercised to give preference to through traffic except that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections.*

(3) *Uncontrolled access means that the authority having jurisdiction over a highway, street, or road does not limit the number of points of ingress or egress except through the exercise of control over the placement and the geometrics of connections as necessary for the safety of the traveling public.*

c. *Date of Public Knowledge of a Proposed Highway Project - the date that the highway agency officially notifies the public of the adoption of the location of a proposed highway project.*

d. *Design Noise Levels* - the noise levels established by this directive for various activities or land uses which represent the upper limit of acceptable traffic noise level conditions. These levels are used to determine the degree of impact of traffic noise on human activities.

e. *Design Year* - the future year used to estimate the probable traffic volume for which a highway is designed. A time 10 to 20 years from the start of construction is usually used.

f. *Existing Noise Levels* - the noise, made up of all the natural and manmade noises, considered to be usually present (unique noise events may be excluded) within a particular area's acoustical environment.

g. *Highway Section* - a finite length of highway proposed for development between logical termini (population centers, major traffic generators, major crossroads, etc.) as normally included in a location study or multiyear highway improvement program.

h. L_{10} - the sound level that is exceeded 10 percent of the time (the 90th percentile) for the period under consideration. This value is an indicator of both the magnitude and frequency of occurrence of the loudest noise events.

i. $L_{10}(h)$ - the hourly value of L_{10}.

j. L_{90} - the sound level that is exceeded 90 percent of the time (the 10th percentile) for the period under consideration.

k. L_{eq} - the equivalent steady state sound level which in a stated period of time would contain the same acoustic energy as the time-varying sound level during the same time period.

l. $L_{eq}(h)$ - the hourly value of L_{eq}.

m. *Level of Service C* - traffic conditions (used and described in the Highway Capacity Manual - Highway Research Board, Special Report 87, 1965) where speed and maneuverability are closely controlled by high volumes, and where drivers are restricted in their freedom to select speed, change lanes, or pass.

Federal-Aid Highway Program Manual Transmittal 192, May 14, 1976

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n. *Location Approval* - *the approval which establishes the general location for a highway section based upon a location study report (in accordance with FHPM 7-7-5) or the adoption of a final environmental impact statement or negative declaration (where the highway agency has implemented paragraph 11b(7) and (8) of the Process Guidelines--FHPM 7-7-1).*

o. *Metropolitan Planning Organization* - *the organization, designated by the Governor, as being responsible, together with the State, for carrying out the provisions of 23 U.S.C. 134, as required by 23 U.S.C. 104(f)(3), and capable of meeting the requirements of 49 U.S.C. 1603(a).*

p. *Noise Level* - *the sound level obtained through use of A-weighting characteristics specified by the American National Standards Institute (ANSI) Standard S1.4-1971. The unit of measure is the decibel (dB), commonly referred to as dBA when A-weighting is used.*

q. *Noise Standards* - *the highway traffic noise studies, noise abatement procedures, coordination requirements, and design noise levels in this directive.*

r. *Operating Speed* - *the highest overall speed at which a driver can travel on a given highway under favorable weather conditions and under prevailing traffic conditions, without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.*

s. *Partial Noise Abatement Measures* - *measures taken to reduce the noise impact but not to a level below the design noise levels.*

t. *Project Development* - *actions described in State action plans developed pursuant to FHPM 7-7-1 (Process Guidelines), and specific studies, surveys, coordination, reviews, approvals, and other activities and steps normally engaged in to determine the location, to perform the design, and to prepare the plans, specifications and estimates for a highway project.*

u. *Traffic Noise Impacts* - *impacts which occur when the predicted traffic noise levels approach or exceed the design noise levels, or when the predicted traffic noise levels substantially exceed the existing noise levels.*

v. *Truck* - *any motor vehicle (including buses) having a gross vehicle weight greater than 10,000 pounds.*

w. *Type IA Project* - a proposed Federal or Federal-aid highway project for construction or reconstruction of a section of highway (or portion thereof) which has either partial or full control of access and for which the highway location is approved after July 1, 1972, or the authorization to advertise for bids for the major grade and drain elements is given after July 1, 1976. Projects unrelated to traffic noise such as lighting, signing, landscaping, safety, etc., are not considered construction or reconstruction of a highway section.

x. *Type IB Project* - a proposed Federal or Federal-aid highway project for construction or reconstruction of a section of highway (or portion thereof) on which the access is uncontrolled and for which the highway location is approved after July 1, 1972, or authorization to advertise for bids for the major grade and drain elements is given after July 1, 1976.

y. *Type II Project* - a proposed Federal or Federal-aid highway project for noise abatement on an existing highway (located on a Federal-aid system) which does not include construction or reconstruction of a highway section (or portion thereof).

z. *Undeveloped Lands* - those tracts of land or portions thereof which do not contain improvements or activities devoted to frequent human habitation or use (including low density recreational use), and for which such improvements or activities are unplanned and not programed.

5. RETROACTIVITY

The requirements of this directive are not retroactive. Approval actions taken prior to the effective date of this directive, in conformance with Policy and Procedure Memorandums 90-2 dated April 26, 1972, subject: Interim Noise Standards and Procedures for Implementing Section 109(i) Title 23, U.S.C., and February 8, 1973, Subject: Noise Standards and Procedures; and FHPM 7-7-3-1 dated February 20, 1974, shall remain in effect.

6. APPLICABILITY

a. *Type IA Projects (Partial and full control of access) - all requirements of this directive (FHPM 7-7-3) apply to all Type IA projects unless it is specifically indicated that a paragraph applies only to Type II projects.*

b. *Type IB Projects (Uncontrolled access) - all requirements of this directive (FHPM 7-7-3), with the exception of paragraphs 7b(6) and 9, apply to all IB projects unless it is specifically indicated that a paragraph applies only to Type II projects.*

c. *Type II Projects (Specifically for noise abatement) - the development and implementation of Type II projects are not mandatory requirements of 23 U.S.C. 109(i) and are therefore not requirements of this directive. When Type II projects are proposed for Federal-aid highway fund participation (at the option of the highway agency) the provisions of paragraphs 7d, e, 12a, c, d, e, and 13 of this directive shall apply.*

d. *Type IA, IB, and II Projects - the plans and specifications for Type IA, IB, and II projects shall not be approved by FHWA unless:*

   (1) *the noise study report has been concurred in by FHWA, and*

   (2) *the project has been developed in accordance with the requirements of this directive.*

e. *Type IA Projects - in addition to the requirements of paragraph 6d, the plans and specifications for Type IA projects shall not be approved by FHWA unless:*

   (1) *noise abatement measures are incorporated to attain reductions to or below the design noise levels for those activities and land uses where predicted noise levels exceed the design noise levels in Figure 3-1, or*

   (2) *partial noise abatement measures are incorporated, where feasible, and exceptions to the design noise levels have been approved by FHWA where the design noise levels cannot be reasonably achieved.*

f. *Type IB Projects - in addition to the requirements of paragraph 6d, the plans and specifications for Type IB projects shall not be approved by FHWA unless the noise abatement measures identified as feasible (as determined by the analysis in paragraph 7b(5)) have been incorporated in the plans and specifications for Type IB projects.*

7. ANALYSIS OF TRAFFIC NOISE IMPACTS AND ABATEMENT MEASURES

a. *In type IA and IB project development, the highway agency shall determine and analyze expected traffic noise impacts and determine the overall benefits which can be achieved by noise abatement measures to mitigate these impacts, giving weight to any adverse social, economic, and environmental effects. The level of analysis may vary from simple calculations for rural and low volume highways to extensive analysis for high volume controlled access highways in urban areas.*

b. *The traffic noise analysis shall be conducted in the following manner:*

(1) *Identify existing activities or land uses which may be affected by noise from the highway section.*

(2) *Predict the traffic noise levels for each alternative under detailed study (including the "do nothing" alternative). Steps 3 through 6 of the traffic noise analysis may be eliminated if it is analytically determined (in accordance with steps 1 and 2) that activities or developed land uses are not sufficiently close to the proposed highway improvement to be adversely affected by traffic noise.*

(3) *Measure the existing noise levels for existing activities or developed land uses. Measurements may not be necessary where it is clear that the existing levels are predominantly from the highway being improved and can be satisfactorily estimated using approved noise prediction methods. The purpose of this noise level information is to quantify the existing acoustic environment and to provide a base for assessing the impact of noise level increases. The descriptors (L_{eq} or L_{10}) used to quantify these measurements shall be consistent with the descriptors used for the predicted levels and the design noise levels in Figure 3-1. Measurement systems shall, as a minimum, meet the requirements for Type 2 instruments as specified in ANSI Standard S1.4-1971.*

(4) *Compare the predicted traffic noise levels for each alternative under detailed study with the existing noise levels and with the design noise levels in Figure 3-1. This comparison shall also include predicted traffic noise levels for the "do nothing" alternative in the design year. Such information shall be used primarily to describe the noise impact of proposed highway improvements in contrast with noise levels likely to be reached in the same area if no highway improvement is undertaken. Noise impacts can be expected when the predicted traffic noise levels (for the design year) approach or exceed the design noise levels in Figure 3-1, or when the predicted traffic noise levels are substantially higher than the existing noise levels. The comparison between predicted traffic noise levels for the proposed action and the "do nothing" alternative (for the design year) may be used in the consideration of exceptions to the design noise levels.*

(5) *Examine and evaluate alternative noise abatement measures for reducing or eliminating the noise impact on existing activities; developed lands; and undeveloped lands for which development is planned, designed and programed. This examination shall include a thorough consideration of traffic management measures (e.g., prohibition of certain vehicle types, time use restrictions for certain vehicle types, modified speed limits, exclusive lane designations, traffic control devices or combinations of such measures). Federal law requires a determination that noise abatement measures needed to implement the noise standards have been incorporated into project plans and specifications before they are approved. Because decisions on noise abatement are prerequisites to determining environmental impacts, and because these impacts influence decisions on adoption of a highway location, it is important that a preliminary determination be made. Before adoption of a highway location, the highway agency shall identify:*

(a) *noise abatement measures which are likely to be incorporated in the project, and*

(b) *noise impacts for which no apparent solution is available.*

(6) *Identify for Type IA projects those lengths of highway (separately for each side of the highway) and those individual land uses where noise abatement measures appear impracticable or not prudent and which may qualify under the exception procedures (paragraph 9a and b).*

c. *Upon completion of the noise analysis for Type IA or IB projects, the highway agency shall prepare a noise study report for FHWA concurrence.*

(1) *The noise study report shall include the following:*

(a) *detailed noise analysis and evaluation information (paragraph 7b),*

(b) *proposed noise abatement measures including descriptive information which portrays their design details, anticipated effectiveness in relation to the design noise levels (paragraph 8) and/or existing noise levels and estimated costs and benefits,*

(c) *requests for exceptions to the design noise levels and supporting information as required and outlined in paragraph 9 (Type IA projects only),*

(d) *discussion of construction noise analysis information, as required in paragraph 13, including proposed contract provisions to minimize or eliminate adverse construction noise impacts, and*

(e) *discussion and documentation of coordination with local officials as required in paragraph 10.*

(2) *The noise study report may be in preparation throughout the project development process but shall be concluded prior to approval of the plans and specifications. Preliminary versions of the report shall be prepared as necessary for environmental statements and for input to decisions on selecting a highway location. Depending on the scope and timeliness of a complete noise report, various sections of the report such as noise impact evaluations, proposed noise abatement measures, noise exception requests, etc., may be processed separately and included in the final report.*

(3) FHWA concurrence in the noise study report shall constitute its approval of all requested exceptions to the design noise levels contained therein and approval of proposed abatement measures contained therein.

d. Highway agencies proposing to use Federal-aid highway funds for Type II projects shall perform a noise analysis similar to that described in paragraph 7b and shall prepare a noise report with recommendations. This noise report shall indicate and describe the noise impacts that have been identified for these type projects. The design noise levels in Figure 3-1 are a suitable yardstick for this determination.

e. In requesting Federal construction funding for a Type II project, the highway agency shall indicate the nature of the proposed Type II project and the relative priority with other potential Type II projects in the State. Some of the suggested factors which may be considered in the development of this relative priority are:

(1) applicable State law,

(2) type of development to be protected,

(3) magnitude of the traffic noise impact,

(4) cost - benefits,

(5) population density of the affected area,

(6) day-night use of the property,

(7) feasibility and practicability of noise abatement at the site,

(8) availability of funds,

(9) existing noise levels,

(10) achievable noise reduction,

(11) intrusiveness of highway noise (L_{10} - L_{90}),

(12) public's attitude,

(13) local governments' efforts to control land use adjacent to the highway,

(14) date of construction of adjoining development,

(15) *increase in traffic noise since the development was constructed,*

(16) *local noise ordinances,*

(17) *feasibility of abating the noise with traffic control measures.*

8. DESIGN NOISE LEVELS

a. *The design noise levels in Figure 3-1 represent a balancing of that which may be desirable and that which may be achievable. Consequently, noise impacts can occur even though the design noise levels are achieved. The design noise levels for Categories A, B, C, and E should be viewed as maximum values, recognizing that in many cases, the achievement of lower noise levels would result in even greater benefits to the community. Every reasonable effort shall be taken to achieve substantial noise reductions when predicted noise levels exceed these design noise levels. However, any significant reduction in the existing or predicted noise level will be a benefit, and partial noise abatement measures shall be included in the project development where they are consistent with overall social, economic, and environmental considerations. On the other hand, the adverse social, economic, and environmental effects of providing abatement measures may be too high. For each case where the circumstances warrant, this directive provides for FHWA approval of exceptions to the design noise levels for Type IA projects. Exceptions are not required for Type IB and Type II projects.*

b. *The design noise levels are to be applied to:*

(1) *those undeveloped lands for which development is planned, designed, and programed on the date of public knowledge of the highway project,*

(2) *those activities and land uses in existence on the date of public knowledge of the highway project,*

(3) *areas which have regular human use and in which a lowered noise level would be of benefit. Such areas would not normally include service stations, junkyards, industrial areas, railroad yards, parking lots, storage*

DESIGN NOISE LEVEL/ACTIVITY RELATIONSHIPS 1/

Activity Category	Design Noise Levels - dBA 2/ $L_{eq}(h)$	Design Noise Levels - dBA 2/ $L_{10}(h)$	Description of Activity Category
A 3/	57 (Exterior)	60 (Exterior)	Tracts of land in which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks or portions of parks, open spaces, or historic districts which are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B 3/	67 (Exterior)	70 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, and parks which are not included in Category A and residences, motels, hotels, public meeting rooms, schools, churches, libraries, and hospitals.
C	72 (Exterior)	75 (Exterior)	Developed lands, properties or activities not included in Categories A or B above.
D	--	--	For requirements on undeveloped lands see paragraphs 11a and c.
E 4/	52 (Interior)	55 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

1/ See Paragraph 8 for method of application.

2/ Either L_{10} or L_{eq} (but not both) design noise levels may be used on a project.

3/ Parks in Categories A and B include all such lands (public or private) which are actually used as parks as well as those public lands officially set aside or designated by a governmental agency as parks on the date of public knowledge of the proposed highway project.

4/ Se Paragraphs 8c, d, and e for method of application.

yards, and the unused open space portions of other developments and facilities. Design noise levels should, however, be applied to those parks and recreational areas or portions thereof where serenity and quiet are considered essential even though such areas may not be subject to frequent human use, and

(4) those places within the sphere of human activity (at approximately ear-level height) where activities actually occur. The values do not apply to an entire tract upon which an activity is based, but only to that portion on which such activity normally occurs.

c. The interior design noise levels in Category E apply to:

(1) indoor activities for those parcels where no exterior noise sensitive land use or activity is identified, and

(2) those situations where the exterior activities on a tract are either remote from the highway or shielded in some manner so that the exterior activities will not be significantly affected by the noise, but the interior activities will.

d. The interior design noise levels in Category E may be considered as a basis for noise insulation of public use institutional structures in special situations when, in the judgment of the highway agency and concurred in by the FHWA, such consideration is in the best public interest.

e. Interior noise level predictions may be computed by subtracting from the predicted exterior levels the noise reduction factors for the building in question. If field measurements of these noise reduction factors are obtained, (or if the factors are calculated from detailed acoustical analyses) the measured (or calculated) values shall be used.

(1) In the absence of such calculations or field measurements, the noise reduction factors may be obtained from the following table:

Building Type	*Window Condition*	*Noise Reduction Due to Exterior of the Structure*
All	*Open*	*10 dB*
Light Frame	*Ordinary Sash (closed)*	*20*
	Storm Windows	*25*
Masonry	*Single Glazed*	*25*
Masonry	*Double Glazed*	*35*

(2) The windows shall be considered open unless there is firm knowledge that the windows are in fact kept closed almost every day of the year.

(3) Situations where open window periods do not coincide with a high traffic noise level may qualify as a closed window condition. In such instances, the optional noise prediction procedures in paragraph 14e shall be used.

9. PROCEDURE FOR REQUESTING EXCEPTIONS TO THE ACHIEVEMENT OF THE DESIGN NOISE LEVELS FOR TYPE IA HIGHWAY PROJECTS

a. There may be situations along Type IA highway projects where the predicted noise levels exceed the design noise levels and the adverse social, economic, and environmental effects of noise abatement measures are considered to exceed the abatement benefits. If this condition is expected to occur, the noise analysis shall include evaluations of adverse effects and the benefits of full and partial reductions of the predicted noise levels.

b. The highway agency may request an exception to the achievement of the specified design noise levels for Type IA projects where it can be demonstrated that the adverse effects exceed the overall benefits. To request an exception, the highway agency shall provide in the noise study report required by paragraph 7c the results of the following:

(1) Identification of the individual noise sensitive activities or groups of activities (including the number of persons affected) along the sections of highway which are

subjected to existing traffic noise levels, or are expected to be subjected to future traffic noise levels, in excess of design levels.

(2) An examination of the overall benefits and adverse effects of partial noise abatement measures.

(3) A weighing of the overall benefits which can be achieved by the noise abatement measures against any adverse effects and other conflicting values such as economic reasonableness, air quality, highway safety, adjacent neighborhood desires about esthetic impact (and other desires), or other similar values. Such weighing shall establish that measures for reduction of noise levels to more desirable levels for that particular activity, land use, or groups of activities are not in the best overall public interest. A principal factor in this weighing shall be the concern for public health, public welfare, and the quality of life. These decisions must ultimately be based upon case-by-case determinations. However, every effort shall be made to obtain detailed information on the costs, benefits, and effects involved to assure that final decisions utilize a systematic and factually based assessment.

(4) Recommendations for incorporation in the project plans and specifications of the partial noise abatement measures determined to have benefits consistent with adverse effects.

c. Exception approvals shall not be granted without a showing that all reasonable options for noise reduction (excluding measures provided by paragraph 12e) have been explored and that the partial noise abatement measures recommended provide the greatest attainable noise reductions consistent with the overall public interest.

d. In most cases, exceptions will be approved when the predicted traffic noise level from the highway project is less than the existing noise level (originating from sources other than the highway being improved or replaced) for the activity or land use in question. In these instances, there should be a reasonable expectation that the noise from the other sources will not be significantly reduced in the future.

10. POLICIES FOR COORDINATION WITH LOCAL OFFICIALS

Pursuant to this directive, FHPM 7-7-1 (Process Guidelines), and FHPM 7-7-5 (Public Hearing and Location/Design Approval) highway agencies have the responsibility for taking measures that are prudent and feasible to assure that the location and design of highways are compatible with existing and planned land uses. Local governments have responsibility for land development control and zoning. Highway agencies can be of considerable assistance to local officials in promoting compatibility between land development and highways. Therefore, for each Type IA and IB project, highway agencies shall cooperate with metropolitan planning organizations and with local officials (within whose jurisdiction the highway project is located) by furnishing:

a. approximate generalized future noise levels (for various distances from the highway improvement) for both developed and undeveloped lands or properties in the immediate vicinity of the project,

b. information that may be useful to local communities to protect future land development from becoming incompatible with anticipated highway noise levels, and

c. the FHWA policy regarding land use development or changes which are initiated after issuance of this directive (as described in paragraph 12c(2)).

11. NOISE ABATEMENT MEASURES FOR LANDS WHICH ARE UNDEVELOPED ON THE DATE OF PUBLIC KNOWLEDGE OF THE PROPOSED HIGHWAY PROJECT

a. Noise abatement measures are not required for lands which are undeveloped on the date of public knowledge of the proposed highway project (except as provided in paragraph 11b).

b. For lands which are undeveloped on the date of public knowledge of the highway project, the highway agency should treat the activity or land use as developed land in the following situations:

(1) the development was planned, designed, and programed before the highway studies and there is firm evidence that the development has been only temporarily delayed, or

(2) *the development is planned, designed, and programed during the highway project planning and design; there is a very high probability of the development being constructed; and the developer has considered the noise impacts to the extent reasonable and practicable.*

c. *A highway agency may request Federal-aid participation in the cost of providing noise abatement measures for undeveloped lands along Type IA and IB projects when the noise analysis demonstrates a need in the following situations:*

(1) *development occurs between the date of public knowledge of the proposed highway project and the actual construction of the project, or*

(2) *the probability of development occurring within a few years is very high and a strong case can be made in favor of providing noise abatement measures as part of the highway project based on consideration of need, expected long term benefits to the public interest, and the difficulty and increased cost of later incorporating abatement measures into either the highway or the development.*

12. FEDERAL PARTICIPATION

a. *General. Federal funds may be used for noise abatement measures in those situations where:*

(1) *a traffic noise impact has been identified,*

(2) *the noise abatement measures will reduce the noise impact, and*

(3) *the overall noise abatement benefits are determined to outweigh the overall adverse social, economic, and environmental effects of the noise abatement measures.*

b. *Type IA and IB Projects. The following noise abatement measures may be incorporated in Type IA and IB projects to reduce highway-generated noise impacts and the costs of such measures may be included in Federal-aid participating project costs:*

(1). *traffic management measures (e.g., traffic control devices and signing for prohibition of certain vehicle types, time use restrictions for certain vehicle types, modified speed limits, and exclusive lane designations),*

(2) alterations of horizontal and vertical alignments,

(3) acquisition of property rights (either in fee or lesser interest) for installation or construction of noise abatement barriers or devices,

(4) installation or construction of noise barriers or devices (including landscaping for esthetic purposes) whether within or outside the highway right-of-way, and

(5) acquisition of real property or interests therein (predominantly unimproved property) to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise and for other noise abatement purposes. Acquisition of a few improved parcels may be included in such buffer zone acquisitions to provide a uniform treatment. In authorizing any buffer zone acquisition, consideration shall be given to the needs and desires of the community, the demonstrated efforts of the community to implement effective land use control for compatibility, and the overall public interest. It is preferred that buffer zone acquisition be performed in conjunction with local zoning, land use controls, or other local government controls imposed or exercised in accordance with a comprehensive plan. Buffer zones shall be obtained by acquisition of the least real property interest practicable that is sufficient to prevent incompatible uses of adversely impacted lands while permitting uses compatible with the highway environment (e.g., negative easements that restrict grantors' use). In certain cases it may be necessary to acquire additional right-of-way in fee simple with the intent to dispose of excess interests in a manner compatible with the highway environment. Proposals of this kind shall be submitted to FHWA for prior approval. Any conveyance of excess right-of-way shall be in accordance with paragraph 7c of FHPM 7-4-2.

c. *Type II Projects*

(1) The Federal share for noise abatement measures on Type II projects shall be the same as that for the Federal-aid system on which the project is located. For Type II projects on the

Interstate System (including completed sections), the Federal share shall be from Federal-aid Interstate funds.

(2) For Type II projects, noise abatement measures will not normally be approved for those activities and land uses which come into existence after the effective date of this directive. However, noise abatement measures may be employed to protect activities and land uses which come into existence after the effective date provided local authorities have taken measures to exercise land use control over the remaining undeveloped lands adjacent to highways in the local jurisdiction to prevent further development of incompatible activities.

(3) The following noise abatement measures may be incorporated in Type II projects to reduce highway-generated noise impacts and the costs of such measures may be included in Federal-aid participating project costs:

(a) acquisition of property rights (either in fee or lesser interest) for installation or construction of noise abatement barriers or devices,

(b) installation or construction of noise barriers or devices (including landscaping for esthetic purposes) whether within or outside the highway right-of-way, and

(c) traffic management measures (e.g., traffic control devices and signing for prohibition of certain vehicle types, time use restrictions for certain vehicle types, modified speed limits, exclusive land designations, traffic control devices, or combinations of such measures).

d. Noise Insulation. In some specific cases, there may be compelling reasons to consider measures to noise insulate structures. Situations of this kind may be considered on a case-by-case basis for Type IA, IB, and II projects when they involve such public use or nonprofit institutional structures as schools, churches, libraries, hospitals, and auditoriums. Proposals of this type, together with the State's recommendation, shall be submitted to FHWA for prior approval action.

e. *Other Abatement Measures.* *There may be situations where:*

(1) especially severe traffic noise impacts exist or are expected, and

(2) the abatement measures listed above are physically infeasible or economically unreasonable.

In these instances, noise abatement measures other than those listed in paragraph 12b-d may be proposed for Types IA, IB, and II projects by the State highway agency and approved by the Regional Federal Highway Administrator on a case-by-case basis when the conditions of paragraph 12a have been met.

13. CONSTRUCTION NOISE

The following general steps are to be performed for all Type IA, IB, and II projects after the effective date of this directive.

a. Identify land uses or activities which may be affected by noise from construction of the highway. The identification is to be performed during the project development studies.

b. Determine the measures which are needed in the contract plans and specifications to minimize or eliminate adverse construction noise impacts to the community. This determination shall include a weighing of the benefits achieved and the overall adverse social, economic and environmental effects of the abatement measures.

c. Incorporate the needed abatement measures in the contract plans and specifications.

14. TRAFFIC NOISE LEVEL PREDICTION METHODS

a. Predicted noise levels to be used in assessing noise impacts shall be obtained from a prediction method approved by FHWA.

b. The prediction method and the noise level predictions shall account for variations in:

(1) traffic characteristics (volume, speed, and truck traffic),

(2) topography (vegetation, barriers, height, and distance), and

(3) *roadway characteristics (configuration and grades).*

c. *The noise prediction method contained in National Cooperative Highway Research Program (NCHRP) Report 117 as modified in NCHRP Report 144; the Barrier Nomograph (form FHWA 1443); and the method contained in Department of Transportation, Transportation Systems Center Report DOT-TSC-FHWA-72-1 are approved for use. Other noise prediction methods or variations of the above, together with supporting and validation information, shall be furnished to the FHWA Office of Environmental Policy for approval prior to their use.*

d. *In predicting noise levels and assessing noise impacts the following traffic characteristics shall be used:*

(1) *Automotive volume - the future volume (reduced for truck traffic) obtained from the lesser of the design hourly volume or the maximum volume which can be handled under traffic level of service C conditions. For automobiles, level of service C is considered to be the combination of speed and volume which creates the worst noise conditions. The average hourly volume for the highest 3 hours on an average day for the design year may be used for those highway sections where the design hourly volume or the level of service C condition is not anticipated to occur on a regular basis during the design year.*

(2) *Speed - the operating speed which corresponds with the design year traffic volume selected in paragraph 14d(1) and the truck traffic predicted from paragraph 14d(3). The operating speed must be consistent with the volume used.*

(3) *Truck volume - the design hourly truck volume shall be used for those cases where either the design hourly volume or level of service C was used for the automobile volume. Where the average hourly volume for the highest 3 hours on an average day was used for automobile traffic, comparable truck volumes should be used.*

e. *As an alternative to paragraph 14d, the highway agency may select traffic characteristics to correspond with the critical times of day and night*

which will create the most adverse traffic noise impacts upon the nearby activities and land uses. When such alternative traffic characteristics are used, a thorough discussion of such alternative characteristics shall be included in the noise study report.

. Appendix

H. Interim Project Development Guidelines: Transmittal 17

PROJECT DEVELOPMENT REPORT

PROJECT DEVELOPMENT BUREAU

DEVELOPMENT DIVISION

NAME: INTERIM PROJECT DEVELOPMENT GUIDELINES TRANSMITTAL NUMBER 17

CHAPTER 5 - PROCESS

PART 4 - NOISE ANALYSIS CONSIDERATIONS

SECTION 1 - FHWA STANDARDS

Prepared by: Environmental Analysis Section

Issuance: July 1, 1976 Effective: May 24, 1976

ABSTRACT

This IPDG promulgates and describes the revised policies and procedures for noise studies pursuant to Section 136(b) of the Federal-Aid Highway Act of 1970 and Section 114 of the Federal-Aid Highway Act of 1973 in the form of final regulations. These regulations are designed to establish comprehensive policies and procedures for dealing with the abatement of highway traffic noise and highway-related construction noise. The regulations describe procedures which must be used in the identification and analysis of noise impacts from proposed highway improvements on any Federal-aid highway system as well as the required examination of measures to mitigate noise impacts and incorporation of feasible mitigation measures into all new highway projects.

In addition to the complete revised Federal directive (FHPM 7-7-3, originally issued as PPM 90-2), these guidelines contain a "Reader's Digest" condensed and reorganized version of the directive that should be more easily understood by the user. This abridgement contains all the essential items of policy and procedure arranged in an expanded outline format with appropriate explanatory material. Thus it can serve as a general guide and a detailed checklist for the preparation of Noise Study Reports.

NEW YORK STATE DEPARTMENT OF TRANSPORTATION
RAYMOND T SCHULER, Commissioner
State C[illegible] s, Albany, New York 12232

SUMMARY

The purpose of this document is to revise current policies and procedures concerning noise standards for use in the planning and design of new highway projects and to incorporate measures for the control of traffic noise on previously constructed highways on any of the Federal-aid systems.

The regulations contain the following significant changes:

1. Exceptions to the design noise levels are no longer required for highway projects on which access is uncontrolled. However, plans for such projects must incorporate all feasible noise abatement measures,

2. Compliance with the regulations is required for all new projects for which the highway location is approved after July 1, 1972, or authorization to advertise for bids (i.e., P.S.&E. approval) is given after July 1, 1976,

3. An additional noise descriptor - the energy equivalent level (L_{eq})- is included for optional use,

4. Certain general measures are required concerning construction noise, and

5. Federal funding policy is expanded to provide greater flexibility to the Regional Federal Highway Administrator in considering proposals to participate in extraordinary noise abatement measures where the noise impacts are especially severe and where more conventional abatement measures are unacceptable for social, economic, environmental, or engineering design reasons.

NOISE STANDARDS

The purpose of this directive is to promulgate:

1. Policies and procedures for noise studies,
2. Policies and procedures for noise abatement measures,
3. Design noise levels, and
4. Requirements for coordination with local officials.

These four items constitute the noise standards mandated by Federal law. All highway projects which are developed in conformance with them shall be deemed in conformance with the FHWA noise standards.

NOISE STUDY REPORT

As part of the project development process, the expected traffic noise impacts shall be determined and analyzed. The level of analysis may vary from simple calculations for rural and low volume highways to extensive analysis for high volume controlled access highways in urban areas. Upon completion of the noise analysis, a noise study report shall be prepared for FHWA concurrence. It shall include the following sections:

1. Detailed noise analysis and evaluation information,
2. Proposed noise abatement measures,
3. Requests for exceptions to the design noise levels and supporting information,
4. Discussion of construction noise analysis information including proposed contract provisions to minimize or eliminate adverse impacts, and
5. Discussion and documentation of coordination with local officials.

FHWA concurrence in the noise study report shall constitute its approval of all requested exceptions to the design noise levels and of all proposed abatement measures.

NOISE ANALYSIS

The detailed noise analysis and evaluation shall be conducted in the following manner:

1. Identify existing activities or land uses which may be affected by noise from the highway section.

2. Predict the traffic noise levels for each alternative under detailed study including the "do nothing" alternative. (Note: the remainder of the analysis may be eliminated if it is determined that the activities or developed land uses are not sufficiently close to the proposed improvement to be adversely affected.)

3. Measure the existing noise levels for existing activities or developed land uses. (Note: Measurements may not be necessary where it is clear that the existing levels are predominantly from the highway being improved and can be satisfactorily estimated.)

4. Compare the predicted traffic noise levels for each alternative with the existing noise levels and with the design noise levels. Noise impacts can be expected when the predicted levels approach or exceed the design noise levels or when the predicted levels are substantially higher than the existing levels.

5. Examine and evaluate alternative noise abatement measures for reducing or eliminating the noise impact on existing activities; developed lands; and undeveloped lands for which development is planned, designed and programmed. (Note: Because decisions on noise abatement are prerequisites to determining environmental impacts, and because these impacts influence decisions on adoption of a highway location, it is important that a preliminary determination be made.) Therefore, before aoption of a highway location, identification shall be made of:

    a. Noise abatement measures which are likely to be incorporated in the project, and

    b. Noise impacts for which no apparent solution is available.

6. Identify for proposed Federal-aid projects to construct or reconstruct a section of highway with either partial or full control of access those lengths of highway (separately for each side of the highway) and those individual land uses where noise abatement measures appear impracticable or not prudent and which may qualify under the exception procedures.

PREDICTION METHODS

Predicted noise levels to be used in assessing noise impacts shall be obtained from a prediction method approved by the FHWA. The noise prediction method contained in National Cooperative Highway Research Program (NCHRP) Report 117 as modified in NCHRP Report 144; the Barrier Nomograph (Form FHWA 1443); and the method contained in U.S. Department of Transportation, Transportation Systems Center Report DOT-TSC-FHWA-72-1 are approved for use. In predicting noise levels and assessing noise impacts the following traffic characteristics shall be used:

1. The future automobile volume obtained from the lesser of the design hourly volume (DHV) or the maximum volume which can be handled under level of service C conditions,

2. The design hourly truck volume shall be used for those cases where either the DHV or level of service C was used for the automobile volume, and

3. The operating speed which corresponds and is consistent with the design year traffic volume selected.

Traffic characteristics may be selected to correspond with the critical times of day or night which will create the most adverse traffic noise impacts.

DESIGN NOISE LEVELS

The exterior design noise levels are to be applied to:

1. Those activities and land uses in existence on the date of public knowledge of the highway project,

2. Those undeveloped lands for which development is planned, designed, and programmed on the date of public knowledge of the highway project,

3. Those places within the sphere of human activity where activities actually occur, and

4. Areas which have regular human use and in which a lowered noise level would be of benefit.

The interior design noise levels apply to:

1. Indoor activities for those parcels where no exterior noise sensitive land use or activity is identified, and

2. Those situations where the exterior activities are either remote from the highway or shielded in some manner so that the exterior activities will not be significantly affected by the noise.

ABATEMENT MEASURES - DEVELOPED LANDS

Federal funds may be used for noise abatement measures in those situations where:

1. A traffic noise impact has been identified,

2. The noise abatement measures will reduce the noise impact, and

3. The overall noise abatement benefits are determined to outweigh the overall social, economic, and environmental effects of the noise abatement measures.

The following noise abatement measures may be incorporated in proposed Federal-aid projects to construct or reconstruct a section of highway in order to reduce traffic-generated noise impacts:

1. Traffic management measures such as:

   a. Prohibition of certain vehicle types,
   b. Time use restrictions for certain vehicle types,
   c. Modified speed limits,
   d. Traffic control devices and signing, and
   e. Exclusive lane designations,

2. Alterations of horizontal and verticle alignments,

3. Acquisition of property rights for installation or construction of noise abatement barriers or devices,

4. Installation or construction of noise barriers or devices (including landscaping for esthetic purposes) whether within or outside of the highway right-of-way, and

5. Acquisition of property (predominantly unimproved) to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise and for other noise abatement purposes.

The following noise abatement measure projects may be incorporated on an existing highway located on a Federal-aid system which does not involve a construction or reconstruction of the highway section:

1. Traffic management measures as listed above,

2. Acquisition of property rights for installation or construction of noise abatement barriers or devices, and

3. Installation or construction of noise barriers or devices (including landscaping for esthetic purposes) whether within or outside of the highway right-of-way.

In some specific cases there may be compelling reasons to consider measures to noise insulate structures. Situations of this kind may be considered on a case-by-case basis when they involve such public use or non-profit institutional structures as schools, churches, libraries, hospitals and auditoriums. There may be additional situations where noise abatement measures other than those listed may be proposed and approved by the Regional Federal Highway Administration on a case-by-case basis when:

1. Especially severe traffic noise impacts exist or are expected, and

2. The abatement measures listed above are physically infeasible or economically unreasonable.

ABATEMENT MEASURES - UNDEVELOPED LANDS

Noise abatement measures are not required for lands which are undeveloped on the date of public knowledge of the proposed highway project. Undeveloped lands should be treated as developed land in the following situations:

1. The development was planned, designed, and programmed before the highway studies but there is firm evidence that the development has been only temporarily delayed, or

2. The development is planned, designed, and programmed during the highway project planning and design; there is a very high probability of the development being constructed; and the developer has considered the noise impacts to the extent reasonable and practicable.

Noise abatement measures may be requested for undeveloped lands when the noise analysis demonstrates a need in the following situations:

1. Development occurs between the date of public knowledge of the proposed highway project and the actual construction of the project, or

2. The probability of development occurring within a few years is very high and a strong case can be made in favor of providing noise abatement measures as part of the highway project based on:

   a. Consideration of need,
   b. Expected long-term benefits to the public interest, and
   c. The difficulty and increased cost of incorporating the measures later.

EXCEPTION REQUESTS

An exception to the achievement of the specified design noise levels may be requested for projects with either partial or full control of access where it can be demonstrated that the adverse effects exceed the overall benefits. To request an exception, the results of the following shall be provided in the noise study report:

1. Identification of the individual noise sensitive activities or groups of activities including the number of persons affected along the sections of highway which are subjected to existing or future traffic noise levels in excess of design levels,

2. An examination of the overall benefits and adverse effects of partial noise abatement measures,

3. A weighting of the overall benefits against any adverse effects and other conflicting values such as:

   a. Economic reasonableness,
   b. Air quality,
   c. Highway safety,
   d. Esthetic impact,
   e. Neighborhood desires, and
   f. Other similar values,

Such weighting shall establish that measures for reduction of noise levels to more desirable levels are not in the best overall public interest. A principal factor in this weighting shall be the concern for public health, welfare, and the quality of life. Every effort shall be made to obtain detailed information on the costs, benefits, and effects involved to assure that final decisions utilize a systematic and factually based assessment.

4. Recommendations of the beneficial partial noise abatement measures for incorporation in the project plans and specifications.

Exception approvals shall not be granted without a showing that all reasonable options for noise reduction have been explored. In most cases, exceptions will be approved when the predicted traffic noise level from the highway is less than the existing noise level originating from sources other than the highway being improved or replaced.

CONSTRUCTION NOISE

The following general steps are to be performed for the construction noise analysis and discussion:

1. Identify land uses or activities which may be affected by noise from construction of the highway,

2. Determine the measures which are needed in the contract plans and specifications to minimize or eliminate adverse construction noise impacts to the community, and

3. Incorporate the needed abatement measures in the contract plans and specifications.

COORDINATION WITH LOCAL OFFICIALS

Since local governments have responsibility for land development control and zoning, the Department shall cooperate with metropolitan planning organizations and with local officials by furnishing:

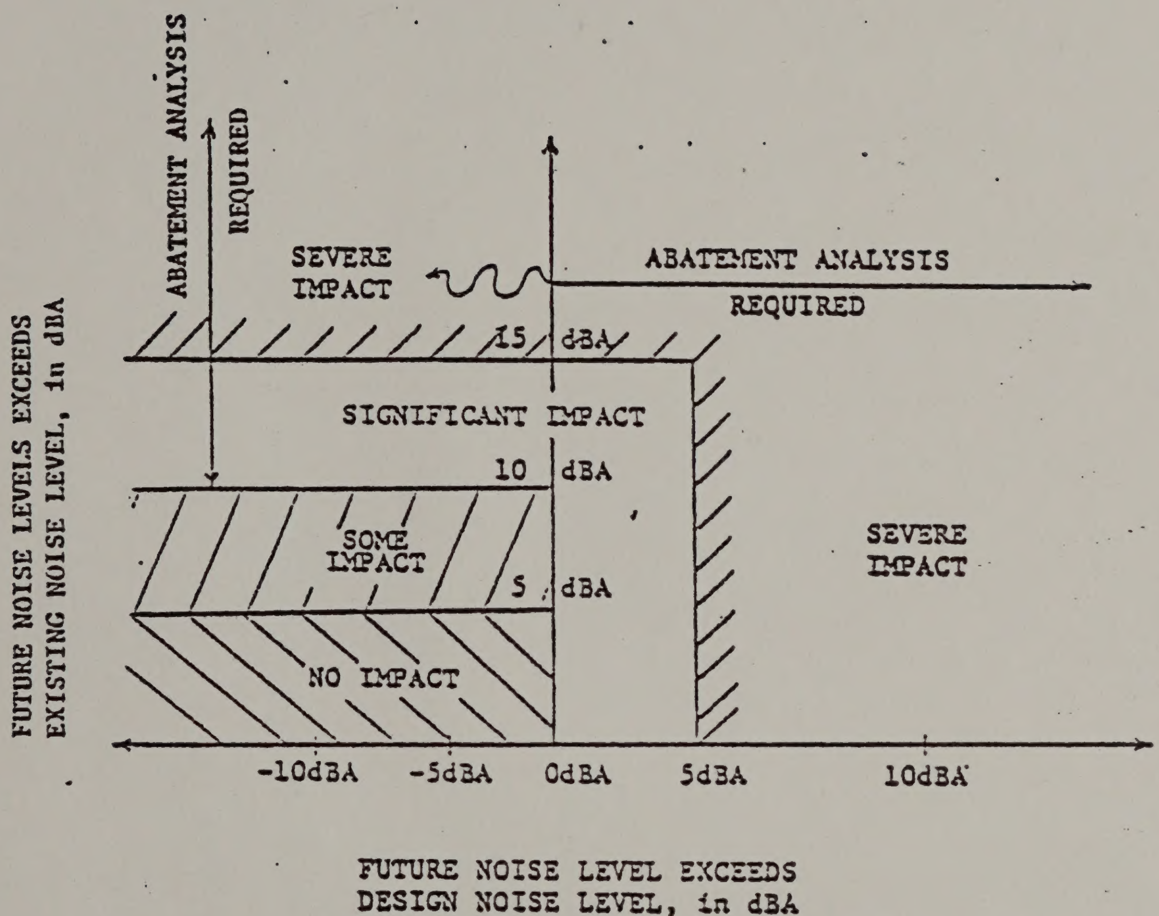
1. Approximate generalized future noise levels for both developed and undeveloped lands in the immediate vicinity of the project,

2. Information that may be useful to protect future land development from being incompatible with anticipated highway noise levels, and

3. The FHWA policy regarding land use development or changes which are initiated in the future.

Appendix

I. Noise Impact Evaluation Model



NOISE IMPACT EVALUATION MODEL